A SURVEY
of
RESEARCH UTILISATION

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Science and Technology

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THE PRODUCTION AND UTILISATION OF KNOWLEDGE IN HIGHER EDUCATION INSTITUTIONS IN SOUTH AFRICA

Volume 2

A survey of research utilisation

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The Production and Utilisation of Knowledge in Higher Education Institutions in South Africa (Volume 2): A Survey of Research Utilisation

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PREFACE

In June 2002, the Carnegie Corporation of New York awarded a substantial grant to CREST – then the Centre for Interdisciplinary Studies – to conduct research on the production and utilisation of research in higher education in South Africa.

In the original proposal to Carnegie, we described the context and rationale behind this project as follows:

> *With the advent of the new democracy in 1994, it was expected that the higher education institutions in the country would and should play a major role in the transformation of South African society. On the one hand, South African universities and technikons were expected to transform themselves; on the other hand, as major actors within the national system of innovation, it was also expected that they would make a significant contribution to the new society in various ways, including the production of relevant and useful knowledge.*
>
> *The focus in the project is on the R&D function of higher education institutions; on the knowledge produced by scientists and scholars at these institutions. In terms of this focus, the overarching aim of the proposed project is to analyse and assess to what extent South African universities and technikons are engaged in a transformative agenda in the production and utilisation of scientific knowledge. Two major research questions will drive the project:*
>
> - *To what extent has the production of scientific knowledge at SA universities and technikons changed over the past seven years?*
> - *To what extent is the knowledge produced at SA universities and technikons used, particularly in the interest of new national goals?*

At the same time as we commenced our work on this project, the National Advisory Council on Innovation placed on tender a national study on the state of research utilisation in South Africa. CREST was awarded a grant to conduct a survey of public sector R&D as well as a separate interview-based study of industry views on research utilisation. We subsequently integrated our work on the Carnegie project and the NACI commission into a two and a half year study. By the end of December 2004 we completed our research.

The findings of this study have been organised into six separate reports:

Volume 1: A review of models of research utilisation
Volume 2: A survey of research utilisation
Volume 3: An industry study of the utilisation of public R&D
Volume 4: The dynamic of knowledge production and utilisation: Fifteen case studies
Volume 5: The role of intermediary organisations in the utilisation of research
Volume 6: Knowledge for transformation: Modes of knowledge production and utilisation in post-apartheid South Africa

The research team wishes to express its gratitude to the National Advisory Council on Innovation for this commission and especially to Dr HC Marais and his staff for their professional support during the study.

We are grateful to all the thousands of respondents who took the time and effort to complete the questionnaires. A special word of thanks is due to all the directors and deans of research at the universities, technikons and science councils who assisted us with the distribution and facilitation of the survey. Without their assistance and support, this study would not have been possible.

A study of this scope invariably relies on teamwork. We have been very fortunate to have a group of dedicated and hard-working individuals who have assisted in various aspects of the study. In particular, we would like to thank the following people:

- Leisl Bowers who assisted with the survey fieldwork.
- Melt van Schoor who designed and managed the web-based data-capturing system for the survey questionnaires and for writing its report.
- Marthie van Niekerk who provided general administrative support to the project.

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CHAPTER 1
INTRODUCTION

1.1 International trends

The late 1970s saw a fundamental shift in the science policy paradigm. After nearly four decades of science policy studies conducted within a "republic of science" paradigm, international trends (cut-backs in government funding of science, the international oil crisis, massification of higher education and a growing disillusionment with science and technology) led to a new emphasis on strategic science and questions about the use and relevance of scientific knowledge production. One of the outcomes of this "paradigm shift" was a new focus on the utility of science and ways of measuring the benefits of knowledge. The formation of a new journal (***Knowledge: Creation, diffusion, utilisation***) in 1979 is just one manifestation of the impact of the new way of thinking on science policy scholars.

In a classic paper in the first volume of the new journal, Fritz Machlup (***Uses, value and benefits of knowledge***) makes a plea for a new approach to measuring the broader economic and social benefits of science. Various subsequent reviews have attempted to map the social and economic benefits of science, including basic research (Hemlin, 1998; Huberman, 1994; Rich, 1997; Salter & Martin, 2001).

Another stimulus to the debates on knowledge utilisation occurred in the early eighties when the Bayh-Doyle Act (which encouraged universities in the USA to acquire property rights for intellectual outputs) was passed. The whole movement towards linkages and partnerships between academia and business/industry was borne. Phenomena such as science parks, technology transfer offices, technology incubators, spin-off companies and so on have been studied extensively (cf. Carstens & Mouton, 2002 for a review of this literature). Again the focus is on the various forms of knowledge utilisation and the impact of new forms both on universities and on industry.

At least four theoretical frameworks have informed these empirical studies. The first was the so-called triple-helix model which was developed by Etzkowitz and Leydesdorff; the second is the so-called agora model developed by Remi Barre (Barre, 2001); the third is the more recent publications on the shift from Mode 1 to Mode 2 knowledge production (Gibbons et al. 1994), and the fourth, is the recent work on "knowledge value alliances" undertaken by Juan Rogers and Barry Bozeman (Rogers & Bozeman, 2001). Our own empirical study is based largely on the theoretical precepts of Bozeman's work (cf. Theoretical framework below).

1.2 Terms of reference

Given the international trends referred to above, it is not surprising that the National Advisory Council on Innovation should commission a national study on research utilisation in South Africa. This is only the second study of its kind in recent years in this country.

The overall project aims were formulated in the Terms of Reference as follows:

- To ascertain the extent to which SA research findings are utilised/implemented (Component awarded to CREST);
- To map the dynamics of the process of implementation; and
- To develop a model of and strategy for the optimisation of the implementation of research findings.

The scope of the project was delineated by two further requirements in the Terms of Reference:

1) that all major R&D institutions across all science cultures are included in the study; and
2) that projects completed by such institutions for the period 1997-1998 be included.

We interpreted these two requirements to imply the following:

- That all significant public sector R&D institutions be included in the study. This means that all current universities (21) and technikons (15), science councils (ARC, CSIR, GSC, HSRC, MINTEK, MRC) and the five national facilities be included in the study.
- The time frame (1997-1998) had been selected to ensure that completed projects, where utilisation of research products could already have materialised, be included.

The detailed survey and methodologies that were employed in the public sector study are discussed in Chapter Two.

1.3 The theoretical framework

Barry Bozeman's recent work on technology transfer (Bozeman, 2002) formed the main theoretical and analytical framework for the empirical study. The framework informed both the design of the questionnaires for the survey as well as the analysis of the survey and interview data. A detailed discussion of Bozeman's framework was presented in our review of the recent scholarship on research utilisation (Bailey & Mouton, 2005). We present a summarised version of that discussion here as background to the empirical studies.

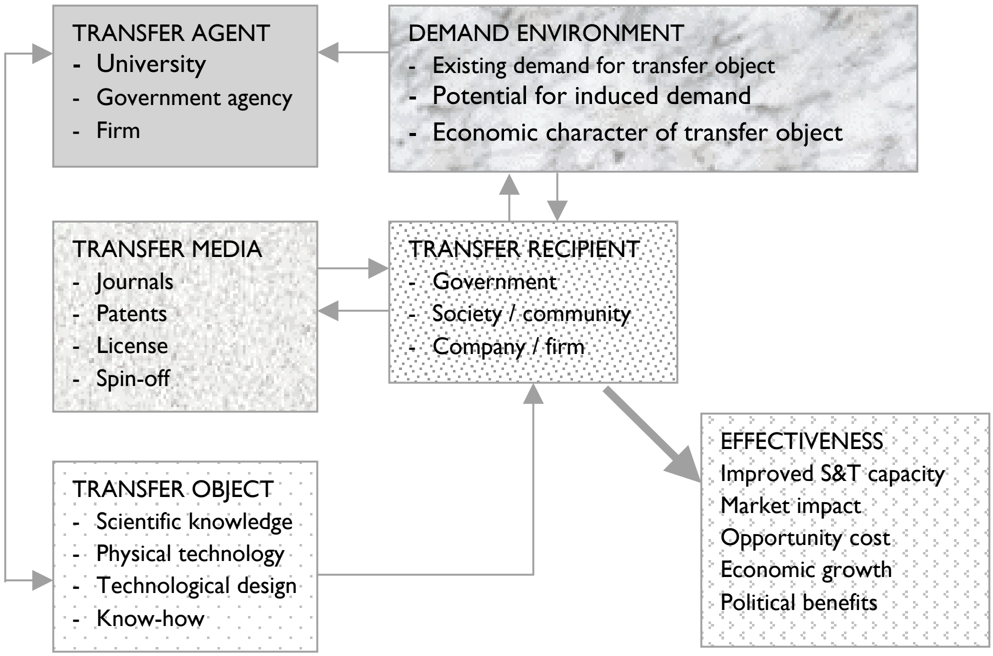
Bozeman's aim is to develop a model that explains the effectiveness of technology transfer processes. He refers to his model as the "contingency effectiveness model" because its main point is that technology transfer effectiveness "can have several meanings, including market impacts, political impacts, impacts on personnel involved and impacts on resources available for other purposes and other scientific and technical objectives" (2002:628).

The CETT model incorporates five main dimensions:

1) characteristics of the transfer agent,
2) characteristics of the transfer medium,
3) characteristics of the transfer object,
4) the demand environment, and

5) (characteristics of the transfer recipient (Cf. Figure 1). In Bozeman's own words: *… the model says that the impacts of technology transfer can be understood in terms of who is doing the transfer, how they are doing it, what is being transferred and to whom (idem: 637).*

Figure 1: The contingency effectiveness model of technology transfer (CETT)



In his review of recent studies on research utilisation, Bozeman discusses the main findings and lessons learnt from this body of scholarship on each of these five dimensions. We summarise some of the most salient conclusions that he draws.

1) Characteristics of the transfer agent

- Etzkowitz (1994, 1998) focused on cultural changes within the new entrepreneurial university environment and shows a culture more conducive to industrially relevant work.
- Various studies (e.g. Lee, 1996) found much less enthusiasm amongst university faculty for business partnerships.
- Slaughter and Rhoades (1996) have focused on the effects of the cooperative paradigm on the structure of academic work, including salary distributions by field and faculty research choices. They suggest that more divisions - especially between the humanities and the natural sciences/engineering - are appearing because of these.

- In earlier studies by Bozeman and Coker (1992) they found that three types of effectiveness related to the transfer agent:

  > *Number of licenses related chiefly to the size of the lab; getting technologies out the door was best explained in terms of the missions of the laboratories and the composition of their R&D; market impact, measured in terms of commercialized technology, was best explained by research diversity and degree of commercial orientation of the lab. (idem: 640)*

2) Characteristics of the transfer medium

- In a comprehensive study of transfer media, Roessner (1993) found that the most important category of interaction was contract research, followed by cooperative research. Few firms valued licensing and more formal interactions.
- The verdict on science parks as a transfer medium remains ambiguous. In a recent study by Felsenstein (1994) it was found that location in a science park seems to provide no direct contribution to innovation but does confer status and prestige and these indirectly promote technology transfer and information flows.
- Not surprisingly, numerous studies increasingly recognize the role of human capital and training in technology transfer. Bozeman refers, amongst others, to work by Bessant and Rush (1995) on consultants, the study of Hicks (1993) on personnel exchange and secondment, and his own work (Bozeman *et al* 1995) on informal relations among bench-level scientists.

3) Characteristics of the transfer object

- Grant and Gregory (1997) have analysed the transfer of 'tacit knowledge' – an area that is receiving new attention – and found that the extent of transfer of tacit knowledge often has a major impact on the effectiveness of manufacturing technology transfer.
- An issue that has also received much attention is the extent to which transfer objects achieve commercialisation and what is their rate of commercial success. Various studies in the US (Roessner, 1993; Bozeman *et al* 1995, Geisler and Clements, 1995) have in fact shown that a minority of interactions are motivated by the prospect of directly realized commercial products. In addition, relatively few projects actually results in the company's commercialisation of technology transferred to the company.
- Where commercialisation is successful, Bozeman (1997) has found that projects were more likely to lead to a commercialised product if they were initiated by either the companies' R&D manager or by top managers in the company.
- Interestingly enough, Rogers and Bozeman (1997) in a study on 219 federal laboratory-industry partnerships, found that projects which involved basic research had higher costs but also a greater likelihood of yielding a commercial technology project.

4) Characteristics of the demand environment

- It is often assumed that the demand for technology is either market-push or market-pull. However, as Dalpe *et al* (1002) show, the role of the public sector as the first user of technological innovations is equally important.
- In a study of technology transfer in the biomedical industry, Azzone and Maccarrone (1997) found that the critical demands for technologies and technical competencies is a major factor in determining market impact technology transfer success.

5) Characteristics of the transfer recipient

- According to Bozeman, studies that have compared business and non-profit or government technology recipients have consistently found significant differences in process, barriers to effectiveness and indeed understandings of what count as effectiveness (Kingsley and Farmer, 1997).
- There is evidence that the cooperative technology policy paradigm is taking hold - at least in the US. In their study interviewing companies' research directors and chief technical officers about sources of external technical knowledge, Roessner and Wise (1994) found that universities fared better than federal laboratories or other firms. However, with respect to sources of technical knowledge for new products and production processes, respondents rated in-house R&D as most important, with universities and government agencies being ranked well below such sources as customers, competitors, suppliers and consultants.

In his final section, Bozeman discusses six effectiveness criteria: "Out of the door" transfer; market impact (e.g. on sales or profitability of the firm); economic development, political effects, opportunity costs and scientific and technical human capital. The advantages and disadvantages of each of these criteria are discussed. At the end of his review, Bozeman points out that despite hundreds of research studies on technology transfer over the recent decades, many topics are still neglected. Although we have learned much, we still know very little about many aspects of the technology transfer process. We quote him in full:

> *We still know almost nothing about technology transfer politics, including distributional outcomes of technology-based economic development. We have little understanding of many critical impacts, such as developments in scientific and technical human capital, occurring over long time periods. We know little about the impact of technology transfer activities on institutions, their designs and their full range of capabilities. (2000:650)*

1.4 Outline of the report

Chapter Two is devoted to a discussion of the research design and methodology of the survey. The main results of the questionnaire survey are presented and discussed in Chapter Three. Copies of the questionnaires are attached as Appendix A.

CHAPTER 2
RESEARCH DESIGN AND METHODOLOGY

2.1 Introduction
The design employed in this study combined an electronic survey of universities, technikons, science councils and national research facilities with telephone interviews with a sample of industry R&D managers.

2.2 The survey instrument
The survey questionnaire was constructed during July and August 2002. It consists of a short biographical section requesting information on an individual level, and a longer section with a project as the unit of inquiry. The latter includes both aspects of knowledge production (research domain, collaboration etc.) and knowledge utilisation (intended beneficiaries, modes of dissemination etc.). In order to complete the project section, the respondents had to select any research project according to the following criteria:

- The project was completed during the previous five years (completion was taken to mean that results or findings had been generated, and/or that the project had been reported on)
- The respondent was the primary/principal investigator or project leader
- The respondent devoted significant research time and resources to the project.

In addition, the project could have been a stand-alone piece of research or embedded within a longer-term research programme.

A first draft of the instrument was distributed to all members of the larger consortium who collaborated on the NACI project, and piloted with a few researchers in the higher education and science council sector. After being altered on the basis of feedback and discussions, the instrument was put onto the web server.

2.3 The web-based survey system
A web-based survey approach was followed, using as sampling frame the e-mail addresses of research staff at universities, technikons and science councils. In Sections 2.3.1 to 2.3.5 below we discuss the procedures used to obtain e-mail addresses from the sampling institutions, as well as the development and implementation of the web-based system, and the questionnaire submission rates.

2.3.1 Development of a sampling frame
The higher education sector
Given the national scope of the survey, and the need to obtain as high as possible a submission rate, it was essential to negotiate the support of the heads of the participating institutions. For universities and technikons it took the form of a personal e-mail, addressed to the Rector or Director of Research, explaining the background and aim of the study. Approval was also sought to send the survey under their name, as well as for

an electronic file of research/academic staff (C1-staff). It was further explained that we would send each person in the file a covering letter via e-mail, together with a hyperlink to the survey questionnaire, which could then be completed on-line. Nine universities and 9 technikons provided us with an electronic list of their C1-staff.

The science council sector

Appointments were scheduled with the CEOs and/or senior management personnel of 6 R&D performing science councils. One of the authors (JM), who facilitated the meetings, used the opportunity to negotiate their assistance, as well as requesting the names and e-mail addresses of research staff. All science councils complied with the request although it had to be followed up with both telephone calls and e-mail reminders.

2.3.2 Development and implementation of the web-based system

The survey was set up on an Internet host located at the University of Stellenbosch. The first step was to import the electronic lists of staff into the web-based system's database. In doing so, each individual was automatically assigned a unique user code, making it possible to track responses (and possible technical problems) by respondent. User codes thus served the dual purpose of keeping track of individuals, as well as providing authenticated access to the questionnaire. Moreover, it made it possible to transparently provide access to the correct version of the questionnaire (i.e. the higher education sector version or the science council version), and access to a choice of language (Afrikaans/English) for staff at traditionally Afrikaans institutions.

Once the staff list of an institution had been imported, and the covering letters finalised, the letters were e-mailed to the respondents. Each letter was personalised and contained a unique URL (web address) that gave access to the questionnaire for that person. E-mail recipients accessed the questionnaire by clicking on the link in their e-mail software. When the correct URL was entered, the respondent directly went to the questionnaire. The respondent then completed the questionnaire in his/her web browser and clicked on a "submit" button at the end of the questionnaire. If submitted successfully, the server captured the user's response and the user was thanked for his/her effort. The server also captured the following:

- The exact time that an e-mail was sent to each respondent
- Whether it was delivered successfully[1]
- The time that the questionnaire was accessed
- The time that the questionnaire was returned.

The e-mailing of covering letters and hyperlinks happened at various stages during September and October 2002. Reminders were posted towards the end of October 2002, but only to users from whom no questionnaire was received.

---

1 The assumption was made that if the mail system did not return an error, the message was delivered successfully. This does not imply that the person had actually read the message, only that the address is very likely to be valid – similar to regular mail.

2.3.3 Evaluation of the web-based system

Generally, the system worked seamlessly, but there were isolated cases of difficulty. A relatively small number of users complained that they were unable to access the questionnaire, which might have been network-related (e.g. network congestion). Similarly, some respondents' computers had errors or faulty set-up. In all of these cases, there was nothing that we could do but asking respondents to try again or to use an alternative computer and/or Internet access provider.

One problem related to our system concerned the requirement of an active user code. An active code enabled a user to log in to the system and to complete one questionnaire only, after which the code was no longer active. Some users, however, found that the computer had submitted the questionnaire before completion. These users were therefore prevented from going back and completing the questionnaire. In such cases, the incomplete questionnaires had to be manually deleted in order to reactivate the user codes.

At one institution, Mintek, a more serious problem occurred. For a reason as yet undetermined, respondents from Mintek experienced errors when attempting to access and/or return the questionnaire. Since completed questionnaires were becoming lost as a result, we eventually decided to shut down access to the system for Mintek users. They were provided with the alternative of a MS Word version of the questionnaire.

2.3.4 Alternative for tertiary institutions that did not provide a list of staff

A number of universities and technikons did not provide us with a list of their C1-staff, but opted to distribute the covering letter internally, despite our most sincere assurances. An alternative to the system described above therefore had to be developed, since it was no longer possible to link information in a respondent database to invitations or to responses. A special link was provided that facilitated open access (i.e. without a user code) to the questionnaire. Most of the advantages of being able to track respondents were lost in this way for some institutions, but it had the advantage of giving freer access to the questionnaire.

2.3.5 Questionnaire submission rates

Tables 2.1 to 2.3 show the questionnaire submission rate by institution.

Table 2.1 Questionnaires returned by universities

University	E-mails sent	E-mails delivered	Reminders sent	Accessed questionnaire	Returned questionnaire	Accessed/ Delivered	Returned/ Delivered
Cape Town[1]	447	244	0	40	17	16%	7%
Durban Westville	Unknown	Unknown	--	1	1	--	--
Fort Hare							
Free State	441	427	355	144	124	34%	29%
Medunsa							
Natal	756	741	639	305	176	41%	24%
North (QwaQwa)	196	117	118	13	6	11%	5%
North-West							
Port Elizabeth	Unknown	Unknown	--	36	16	--	--
Potchefstroom	516	495	399	200	133	40%	27%
Pretoria	Unknown	Unknown	--	391	135	--	--
Rand Afrikaans	368	351	288	135	85	38%	24%
Rhodes	305	274	215	128	96	47%	35%
South Africa[1]	1273	1230	0	98	61	8%	5%
Stellenbosch	769	748	625	312	214	42%	29%
Transkei							
Venda							
Vista	549	460	423	148	87	32%	19%
Western Cape	Unknown	Unknown	--	37	9	--	--
Witwatersrand	Unknown	Unknown	--	100	25	--	--
Zululand[2]	28	28	25	12	7	43%	25%
Total (Known)[3]	5648	5115	3087	1535	1006	30%	20%
Total (All)	--	--	--	2100	1192	--	--

Blank cells that are merged mean that the university was not surveyed.

"Unknown" means that the university distributed the e-mails.

[1] No list of C1-staff provided. We used e-mail addresses from SA Knowledgebase.

[2] E-mails only sent to the Faculty of Science.

[3] Universities where the number of e-mails sent/delivered is known.

Table 2.2 Questionnaires returned by technikons

Technikon	E-mails sent	E-mails delivered	Reminders sent	Accessed questionnaire	Returned questionnaire	Accessed/ Delivered	Returned/ Delivered
Border	160	158	0	42	20	27%	13%
Cape	Unknown	Unknown	--	1	0	--	--
Dbn Inst of Tech	49	45	41	16	10	36%	22%
Eastern Cape							
Free State	Unknown	Unknown	--	3	1	--	--
Mangosuthu	54	54	52	9	4	17%	7%
North. Gauteng	252	242	223	77	32	32%	13%
North-West							
Peninsula	224	199	183	56	25	28%	13%
Pretoria							
Port Elizabeth	278	259	205	128	76	49%	29%
South Africa	93	80	63	41	28	51%	35%
Vaal Triangle	63	60	61	39	24	65%	38%
Witwatersrand	164	163	149	41	21	25%	13%
Total (Known)[1]	1337	1260	977	449	240	36%	19%
Total (All)	--	--	--	453	241	--	--

Blank cells that are merged mean that the technikon was not surveyed.
"Unknown" means that the technikon distributed the e-mails.
[1] Technikons where the number of e-mails sent/delivered is known.

Table 2.3 Questionnaires returned by science councils

Institution	E-mails sent	E-mails delivered	Reminders sent	Accessed questionnaire	Returned questionnaire	Accessed/ Delivered	Returned/ Delivered
ARC	872	773	669	351	206	45%	27%
CSIR	1185	1185	1023	552	273	47%	23%
Geoscience	139	139	122	82	51	59%	37%
HSRC	111	92	74	42	25	46%	27%
Mintek[1]	202	166	0	95	25	57%	15%
MRC	336	185	161	105	43	57%	23%
SAAO	14	14	13	7	2	50%	14%
Total	2859	2554	2062	1234	625	48%	24%

[1] We have captured the completed questionnaires for Mintek manually onto the system.

A total of 2 058 questionnaires was received. In Section 3.2.2 we examine the extent to which the projects in the sample represent the universe of projects in the higher education and science council sectors for 2000.

CHAPTER 3
SURVEY RESULTS

3.1 Introduction

The key findings of the public sector survey into research utilisation is presented and discussed under three sections. In the first section, the key features of the reported projects are discussed with reference to the following:

- The project leader
- Size of project funding
- Research classification of project activities
- Project collaboration
- Expected value or outcome of the project research
- Intended beneficiaries of the research
- Involvement of postgraduate students
- Diffusion and dissemination of the project research

The second main section of Chapter 3 is devoted to a discussion of the bivariate analyses of the data. The following variables were cross-tabulated with the key dependent variable of the study: whether the utilisation of research findings has been effective or not.

- Sector of R&D performance
- Motive or reason for the research
- Broad research domain
- Research experience of project leader
- Time devoted to the project
- Size of project funding
- Project collaboration
- Intended beneficiaries of the research

In the final section of Chapter 3, we present the results of a number of multivariate (CHAID) analyses, where the following variables were analysed in their relationship to effective utilisation:

- Broad research domain
- Research experience of project leader
- Time devoted to the project
- Size of project funding
- Project collaboration

These analyses were done separately for the higher education sector and the science council sector.

3.2 Description of research projects

As highlighted in the methodology section, a total of 2 058 questionnaires was received, of which the majority (58%) are in the university sector (Table 2.1). Since the research project is the unit of analysis, our analyses are based on the subset of 1 803 respondents (88% of total) who provided details about their research projects.

Table 3.1 Survey respondents and research projects by sector of R&D performance

Sector	Respondents		Projects	
	N	%	N	%
Science councils	**625**	**30**	**539**	**30**
Universities	**1192**	**58**	**1081**	**60**
Technikons	**241**	**12**	**183**	**10**
Total	**2058**	**100**	**1803**	**100**

In sections 3.2.1 to 3.2.8 we consider various aspects of the research projects.

3.2.1 The project leader

Table 3.2 gives the profile of the project leaders in terms of gender, highest educational qualification completed, age and years of research experience. The breakdown is per sector.

Table 3.2 Basic profile of project leaders, per sector

Variables	All sectors	Science councils	Universities	Technikons
CATEGORICAL VARIABLES (%)				
Gender				
Female	**37**	**32**	**38**	**43**
Male	**63**	**68**	**62**	**57**
Highest qualification				
Bachelors/ HDip	**5**	**13**	**1**	**11**
Honours	**9**	**13**	**6**	**11**
Masters	**31**	**39**	**24**	**51**
Doctorate	**52**	**31**	**66**	**25**
Other	**3**	**4**	**3**	**2**
SCALE VARIABLES (in years)				
Age				
Mean	**43.8**	**41.3**	**45.2**	**43.3**
Median	**44.0**	**41.0**	**46.0**	**43.0**
Research experience				
Mean	**13.7**	**14.1**	**14.5**	**7.6**
Median	**12.0**	**13.0**	**12.0**	**5.0**

As expected, the project leaders are predominantly male (more so however in science councils and universities than in technikons). Those in the technikon sector have recorded the least research experience (a median of 5 years versus 12-13 years for the other sectors). Also, markedly more projects leaders at universities have doctoral degrees than those at technikons and science councils. The average age across the sample is about 44 years.

3.2.2 Size of project funding

The project leaders specified the amount of funding received for the project, which includes all grants, awards and contract monies. These are shown in Table 3.3.

Table 3.3 Project funding per sector

Funding category	N	%
Higher education sector		
Less than R50 000	672	57.7
R50 000 – R99 000	141	12.1
R100 000 – R249 000	140	12.0
R250 000 – R499 000	72	6.2
R500 000 – R999 000	64	5.5
R1 000 000 – R2 000 000	43	3.7
More than R2 000 000	33	2.8
Total	1165	100.0
Science council sector		
Less than R250 000	217	42.1
R250 000 – R499 000	96	18.6
R500 000 – R999 000	78	15.1
R1 000 000 – R1 999 000	50	9.7
R2 000 000 – R5 000 000	38	7.4
More than R5 000 000	37	7.2
Total	516	100.0

Apart from throwing light on the size and scope of projects, project funding can also be used to determine the extent of sample representation – the extent to which the sample actually reflects the universe of projects in the higher education and science council sectors. We have done so by expressing the total project funding as a percentage of public R&D expenditure.

For any project an exact funding amount was calculated by using the interval mid-point as estimate. This gives a total funding of R791.6 million, based on 1 681 projects. If we replace the missing values for each sector by its modal funding (the value with the highest frequency), the total project funding amounts to R799.2 million (R535.5 million for science councils and R263.7 million for higher education). However, this covers all projects in their total duration, which may be more than 30 years in some cases. Also, not all the projects have the same years in common (e.g. some started in 1995 but ended in 1999 whereas others started in 2001 and are still ongoing). The year that the majority of projects (N = 1 148 or 64% of total) have in common is 2000. Thus, if we want to obtain an estimate of our coverage of projects in terms of its share of public R&D expenditure it would be best to use 2000 as reference year as shown in Table 3.4.

Table 3.4 Project funding for 2000 as a percentage of total R&D expenditure (R millions)

Sector	Project funding for 2000	Total R&D expenditure for 2000	Project as % of total R&D
Science councils (N = 350)	**371.0**	**1 770.0**	**21%**
Higher education (N = 798)	**202.3**	**1 100.0**	**18%**
Total (N = 1 148)	**573.3**	**2 870.0**	**20%**

According to Table 3.4 our sample of projects, in terms of funding for 2000, covers about 20% of all public R&D expenditure in the higher education and science council sectors. (The figures for total R&D expenditure are from a chapter on science policy indicators that CREST has submitted to the HSRC for the latter's HRD Review.)

3.2.3 Research classification of project activities

The project leaders were asked to indicate in which broad research domain their research activities mainly fall. Eighteen domains were provided and they could tick as many as applying to their project. Table 3.5 gives the results (in terms of percentages) per sector.

Table 3.5 Broad research domain of project activities, per sector

Domain	All sectors	Science councils	Universities	Technikons
Social sciences	**24.6**	**12.4**	**29.2**	**32.8**
Applied sciences & technologies	**19.2**	**33.4**	**11.8**	**21.3**
Arts and humanities	**19.1**	**3.2**	**26.3**	**24.0**
Agricultural sciences	**18.2**	**37.7**	**10.8**	**4.9**
Health sciences	**16.7**	**14.1**	**19.1**	**10.4**
Biological sciences	**16.6**	**23.6**	**15.2**	**4.9**
Environmental sciences	**15.6**	**27.3**	**10.4**	**12.0**
Economic & management sciences	**13.9**	**9.8**	**15.1**	**18.6**
Engineering sciences	**12.0**	**21.2**	**7.4**	**12.6**
Information & communication technologies	**7.9**	**9.6**	**6.3**	**12.6**
Earth sciences	**7.3**	**16.0**	**3.7**	**3.3**
Chemical sciences	**7.2**	**11.1**	**5.1**	**7.7**
Medical sciences: Basic	**5.1**	**3.7**	**6.3**	**2.2**
Mathematical sciences	**4.9**	**4.5**	**5.0**	**6.0**
Material sciences	**4.3**	**5.8**	**3.2**	**6.0**
Physical sciences	**4.3**	**3.9**	**4.3**	**4.9**
Medical sciences: Clinical	**3.7**	**3.2**	**4.2**	**2.2**
Marine sciences	**2.1**	**3.2**	**1.9**	**0.0**

The projects housed at science councils largely fall within the domain of agricultural sciences (37.7%), applied sciences and technologies (33.4%), and environmental sciences (27.3%). The social sciences (29.2% and 32.8%) and arts and humanities (26.3% and 24.0%) rank among the top two domains at the higher education institutions. Health sciences (19.1%) and applied sciences and technologies (21.3%) rank third at universities and technikons respectively. The broad research domains were subsequently classed into three science culture categories (SS = social sciences, NS = natural sciences, H&MS = health and medical sciences) [2] and possible combinations thereof. These are displayed in Table 3.6.

Table 3.6 Science culture of project activities, per sector

Science culture	All sectors		Science councils		Universities		Technikons	
	N	%	N	%	N	%	N	%
NS	**735**	**41**	**371**	**69**	**307**	**29**	**57**	**31**
SS	**540**	**30**	**26**	**5**	**437**	**41**	**77**	**43**
SS / NS	**168**	**10**	**52**	**10**	**91**	**8**	**25**	**14**
H&MS	**135**	**8**	**20**	**4**	**106**	**10**	**9**	**5**
H&MS / NS	**110**	**6**	**40**	**7**	**63**	**6**	**7**	**4**
SS / H&MS	**59**	**3**	**11**	**2**	**46**	**4**	**2**	**1**
SS / H&MS / NS	**42**	**2**	**16**	**3**	**22**	**2**	**4**	**2**
Total	**1789**	**100**	**536**	**100**	**1072**	**100**	**181**	**100**

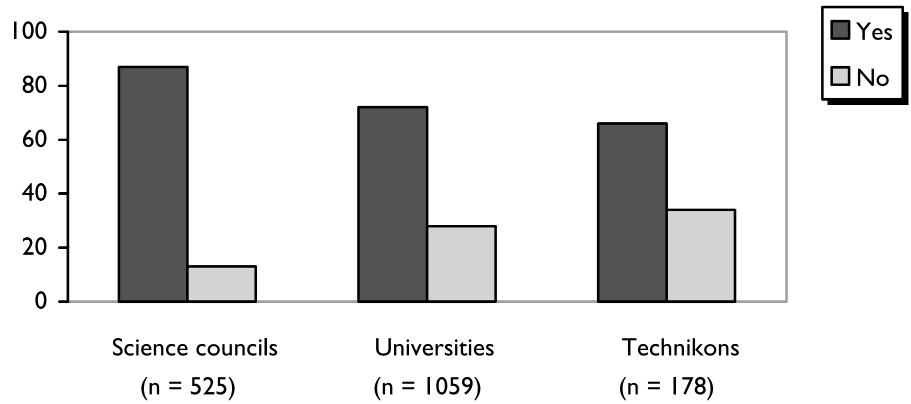
It is apparent from Table 3.6 that projects associated with a single science culture are prominent within all sectors. In the case of science councils it is mostly natural sciences projects (69%). For higher education institutions it is projects of a social sciences nature (41% and 43% for universities and technikons), followed by natural sciences projects (29% and 31%).

3.2.4 Project collaboration

Information was also obtained as to whether or not the project leaders collaborated with others on the project. As can be seen in Figure 3.1, the highest incidence of collaborative activities (87%) occurred in the science council sector.

2 SS = Arts and Humanities, Economic and Management Sciences, Social Sciences
H&MS = Health Sciences, Medical Sciences: Basic & Clinical
NS = All the others

Figure 3.1 Incidence of research collaboration, per sector



In which sectors do the collaborators work? According to Table 3.7 the collaborators are mostly fellow academics and scholars, although less so for technikons. Also, science councils have the greatest variation in collaboration, as they have the highest incidences of collaboration with industry/business, government, other sciences councils and NGOs.

Table 3.7 Sector of collaboration, per institutional classification

Collaborated with…	All sectors		Science councils		Universities		Technikons	
	N	%	N	%	N	%	N	%
Academics / scholars	**1076**	**59.7**	**300**	**55.7**	**685**	**63.4**	**91**	**49.7**
Industry/ business	**422**	**23.4**	**215**	**39.9**	**167**	**15.4**	**40**	**21.9**
Government	**284**	**15.8**	**144**	**26.7**	**115**	**10.6**	**25**	**13.7**
Science council(s)	**231**	**12.8**	**179**	**33.2**	**46**	**4.3**	**6**	**3.3**
NGOs	**160**	**8.9**	**70**	**13.0**	**75**	**6.9**	**15**	**8.2**

3.2.5 Expected value or outcome of the project research

The project leaders could select from a list of 13 potential outcomes those three that, in their opinion, best describe the overall expected value or outcome of the research. From Table 3.8 it is clear that "advancing or improving knowledge" was the single most important expected outcome in all sectors (ranging between 63.4% and 72.2%). In the higher education sector the development of skills and competencies and the training of students assumed second and third places (although in reversed order for universities and technikons). Skills and competency development also ranks highly in the science council sector, together with solving of immediate technical and applied problems.

Table 3.8 Expected value/ outcome of the research, per sector

Expected value / outcome	All sectors	Science council	University	Technikon
Advancement in knowledge	**69.5**	**66.0**	**72.2**	**63.4**
Development of skills and competencies	**33.0**	**34.0**	**32.0**	**36.1**
Training of students	**29.7**	**10.6**	**38.6**	**33.9**
Solving immediate technical applied problems	**24.3**	**39.0**	**17.7**	**20.2**
Influenced decision-makers	**21.7**	**23.6**	**21.2**	**19.1**
Solving environmental or social problems	**21.2**	**25.2**	**19.3**	**20.2**
Change in behaviour/ attitudes/ values	**18.7**	**11.5**	**20.8**	**27.9**
Development of new technology	**14.4**	**23.4**	**9.9**	**14.8**
Solving of theoretical problems	**13.1**	**8.9**	**16.1**	**7.7**
Improved product or technical design	**8.3**	**12.2**	**6.6**	**7.1**
Change legislation	**4.0**	**5.2**	**3.7**	**2.2**
Entrance into new markets	**3.4**	**6.9**	**1.9**	**2.7**
Engineered a prototype	**3.1**	**4.5**	**2.4**	**2.7**

For each outcome or value selected, the project leader indicated the extent to which he/she believed that the outcome has been successfully attained. Three options were given: highly successful, successful to some extent, and not successful at all (Table 3.9).

Table 3.9 Successful attainment of research outcome

Expected value / outcome	Successful (%)				Number of projects
	Highly	To some extent	Not at all	No response	
Advancement or improvement in knowledge	**67.7**	**30.3**	**0.4**	**1.6**	**1253**
Training of students	**66.6**	**30.8**	**0.6**	**2.0**	**536**
Engineered a prototype	**60.0**	**34.5**	**0.0**	**5.5**	**55**
Development of skills and competencies	**56.8**	**40.0**	**1.7**	**1.5**	**595**
Development of new technology	**53.5**	**43.1**	**1.9**	**1.5**	**260**
Improved product or technical design	**53.3**	**41.3**	**3.3**	**2.1**	**150**
Solving immediate technical / applied problems	**52.7**	**45.2**	**0.7**	**1.4**	**438**

Table 3.9 Continued

Expected value / outcome	Successful (%)				Number of projects
	Highly	To some extent	Not at all	No response	
Solving of theoretical problems	**41.9**	**53.4**	**0.8**	**3.9**	**236**
Entrance into new markets	**37.1**	**53.2**	**8.1**	**1.6**	**62**
Influenced decision-makers	**28.4**	**58.8**	**11.0**	**1.8**	**391**
Solving environmental or social problems	**27.7**	**65.4**	**5.0**	**1.9**	**382**
Change in behaviour/ attitudes/ values	**27.2**	**64.8**	**6.2**	**1.8**	**338**
Change legislation	**18.1**	**58.3**	**19.4**	**4.2**	**72**

Not surprisingly, the rankings in Table 3.9 reveal that project outcomes, which are more under the "control" of the principal investigator, such as the advancement of knowledge or capacity building are more likely to be successfully attained. Conversely where projects outcomes relate to a form of broader social intervention (such as changing legislation, values, or solving environmental or social problems) or change in behaviour, the expected success rate is much lower. Another dimension that seems to underpin these results is whether the expected outcome is of a more theoretical/conceptual nature (advancing knowledge) or of a more practical/applied nature (solving problems). In this case, it appears as if projects with more theoretical/conceptual outcomes are also seen as more likely to successfully have attained their outcomes.

3.2.6 Intended beneficiaries of the research

Table 3.10 indicates which intended beneficiaries the project leaders had in mind when they conceptualised the research.

Table 3.10 Those intended to benefit by the research

Intended beneficiary	N	%
Colleagues/scholars/peers in own discipline	**1079**	**59.8**
General public/ society/ community	**553**	**30.7**
Industry/ firms	**546**	**30.3**
Specific interest groups (e.g. farmers, consumers)	**530**	**29.4**
Government	**514**	**28.5**
Colleagues/scholars/peers in other disciplines	**466**	**25.8**
The contracting agency	**271**	**15.0**

In Table 3.10 the majority of project leaders said that they expect colleagues or scholars in their own discipline to benefit from the research. This is not surprising, given the prominence of advancement or improvement in knowledge as a project outcome. Only in

15% of cases has the contracting agency been reported as an intended beneficiary. The distribution of responses by sector is shown in Table 3.11.

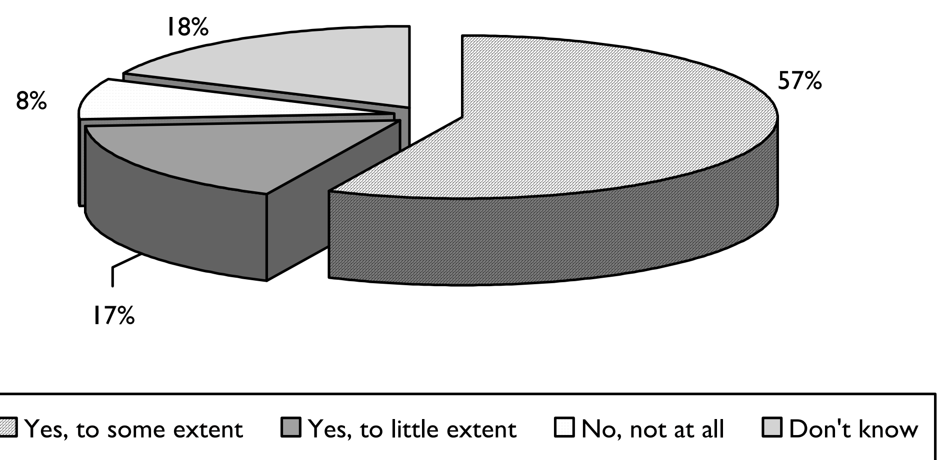
Table 3.11 Intended beneficiaries, per sector

Intended beneficiary	Science councils		Universities		Technikons	
	N	%	N	%	N	%
Colleagues/scholars/peers in own discipline	**228**	**42.3**	**739**	**68.4**	**112**	**61.2**
Colleagues/scholars/peers in other disciplines	**97**	**18.0**	**326**	**30.2**	**43**	**23.5**
The contracting agency	**126**	**23.4**	**135**	**12.5**	**10**	**5.5**
Industry/ firms	**225**	**41.7**	**250**	**23.1**	**71**	**38.8**
Government	**206**	**38.2**	**262**	**24.2**	**46**	**25.1**
Specific interest groups (e.g. farmers, consumers)	**222**	**41.2**	**275**	**25.4**	**33**	**18.0**
General public/ society/ community	**172**	**31.9**	**330**	**30.5**	**51**	**27.9**

Colleagues in one's own discipline are more likely to be specified as intended beneficiaries in the two sectors of higher education, compared to the science council sector (68.4% and 61.2% versus 42.3%). Colleagues in other disciplines also feature strongest in the university sector. There appears a greater tendency for technikons and science councils to identify industry and firms as beneficiaries. Also, science councils have a relatively larger component of projects directed at specific interest groups.

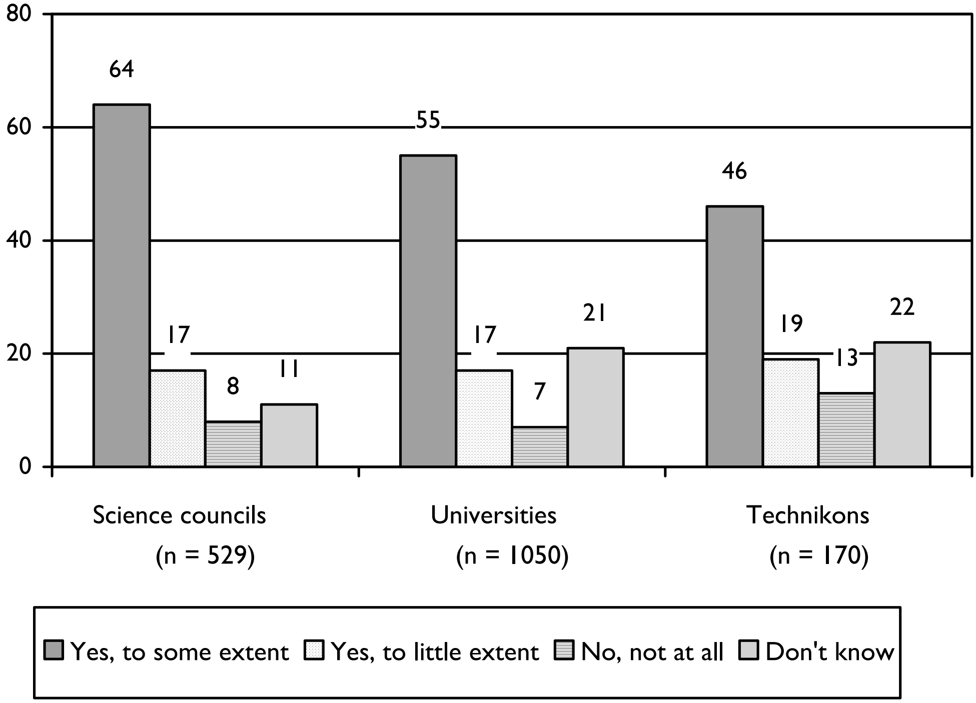
Did the intended beneficiaries recognise or utilise the research as planned? Of the 1 749 project leaders who responded to this question, 57% said yes, the intended beneficiaries did to some extent (Figure 3.2).

Figure 3.2 Did the intended beneficiaries recognise/ utilise/ implement the research as planned?



A breakdown by sector appears in Figure 3.3. Here the extent of research utilisation is greatest for science councils, followed by universities and technikons.

Figure 3.3 Utilisation of research by intended beneficiaries, per sector



3.2.7 Involvement of postgraduate students

Postgraduate students more than often play an integral role in the utilisation of research; apart from being intended beneficiaries (through skills development etc.) they also act as transfer agents in the sense that the (tacit) skills and knowledge acquired on the project are transferred to and drawn upon in their work environment. We therefore asked the project leaders whether any postgraduate students worked on the project (Figure 3.4), and if so, how many masters and doctoral students received (or were expected to receive) their degree because of the research (Table 3.12).

As can be seen in Figure 3.4 more students worked on university projects than on science council and technikon projects. On average, however, the larger number of doctoral students graduating from the project appears to be in the technikon sector.

Figure 3.4 Involvement of postgraduate students, per sector

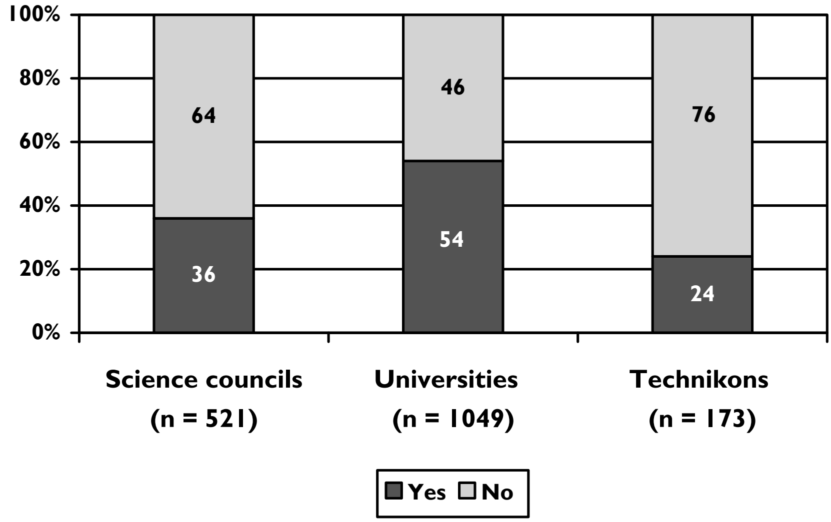


Table 3.12 Masters and doctoral students that graduated, per sector

Sector		Masters graduates	Doctoral graduates
Science councils	Mean	1.86	1.13
	N	143	99
Universities	Mean	3.90	1.86
	N	465	314
Technikons	Mean	2.57	1.95
	N	35	22
Total	Mean	3.37	1.70
	N	643	435

3.2.8 Diffusion and dissemination of the project research

Project findings may be disseminated in various ways. We asked the project leaders to indicate how they have communicated the results of their research, by selecting from 27 modes of communications, grouped together in six broad categories. The responses are summarised in Table 3.13.

Table 3.13 Communication of research results

Mode of communication	N	%
Publications and documents		
Articles in refereed scientific journals	**983**	**54.5**
Published conference proceedings	**843**	**46.8**
Contract reports	**690**	**38.3**
Articles in popular journals	**400**	**22.2**
Chapters in books	**274**	**15.2**
Books/ monographs	**204**	**11.3**
Technical manuals	**194**	**10.8**
Written input to official policy documents	**165**	**9.2**
Articles in refereed technical journals	**129**	**7.2**
Presentations		
Predominantly academic audiences	**1294**	**71.8**
Predominantly non-academic audiences	**639**	**35.4**
Expert committees/ panels	**452**	**25.1**
Fairs/ exhibitions/ road shows	**203**	**11.3**
Public hearings	**112**	**6.2**
Patents /licenses		
Through patenting	**78**	**4.3**
Through licensing	**31**	**1.7**
Training and supervision		
Supervision of masters/ doctoral students	**593**	**32.9**
Training through workshops	**499**	**27.7**
Training through coursework	**384**	**21.3**
Cooperative interactions/ informal meetings		
Informal meetings with potential users/ teams	**713**	**39.5**
Consultations/ technical assistance to potential users	**608**	**33.7**
Personnel exchanges/ secondments	**329**	**18.2**
Organisational structures		
Through participation in consortia	**212**	**11.8**
Through spin-off companies	**52**	**2.9**
Through technology transfer offices	**52**	**2.9**
Through technology incubators	**23**	**1.3**
Through science parks	**19**	**1.1**

As can be seen in Table 3.13 the five most important modes of communication are:

- Presentations to predominantly academic audiences;
- Articles in refereed scientific journals;
- Published conference proceedings;
- Informal meetings with potential users and teams, and
- Contract reports.

If we cross tabulate the modes of communication by the sector of R&D performance (Table 3.14) then the only mode of communication that constitutes one of the top three in all the sectors is presentations to predominantly academic audiences. Contract reports as a way of dissemination are mostly of importance to the science council sector. Articles in refereed scientific journals particularly apply to the university sector.

Table 3.14 Communication of research results, per sector

Mode of communication	Science councils		Universities		Technikons	
	N	%	N	%	N	%
Publications and documents						
Articles in refereed scientific journals	214	39.7	715	66.1	54	29.5
Articles in refereed technical journals	54	10.0	65	6.0	10	5.5
Articles in popular journals	158	29.3	223	20.6	19	10.4
Contract reports	342	63.5	319	29.5	29	15.8
Books/ monographs	43	8.0	142	13.1	19	10.4
Chapters in books	63	11.7	196	18.1	15	8.2
Published conference proceedings	265	49.2	495	45.8	83	45.4
Written input to official policy documents	60	11.1	91	8.4	14	7.7
Technical manuals	105	19.5	81	7.5	8	4.4
Presentations						
Academic audiences	331	61.4	837	77.4	126	68.9
Non-academic audiences	247	45.8	343	31.7	49	26.8
Expert committees/ panels	191	35.4	232	21.5	29	15.8
Public hearings	40	7.4	64	5.9	8	4.4
Fairs/ exhibitions/ road shows	98	18.2	88	8.1	17	9.3
Patents/ licences						
Through patenting	33	6.1	39	3.6	6	3.3
Through licensing	19	3.5	12	1.1	0	0.0

Table 3.14 Continued

Mode of communication	Science councils		Universities		Technikons	
	N	%	N	%	N	%
Training and supervision						
Training through workshops	**162**	**30.1**	**283**	**26.2**	**54**	**29.5**
Training through coursework	**74**	**13.7**	**275**	**25.4**	**35**	**19.1**
Supervision of masters/ doctoral students	**86**	**16.0**	**468**	**43.3**	**40**	**21.9**
Cooperative interactions/ informal meetings						
Consultations/ technical assistance to potential users	**250**	**46.4**	**300**	**27.8**	**58**	**31.7**
Personnel exchanges/ secondments	**142**	**26.3**	**160**	**14.8**	**27**	**14.8**
Informal meetings with potential users/ teams	**281**	**52.1**	**357**	**33.0**	**75**	**41.0**
Through participation in consortia	**112**	**20.8**	**87**	**8.0**	**13**	**7.1**
Through science parks	**6**	**1.1**	**13**	**1.2**	**37**	**20.2**
Through spin-off companies	**21**	**3.9**	**30**	**2.8**	**1**	**0.5**
Through technology transfer offices	**36**	**6.7**	**15**	**1.4**	**1**	**0.5**
Through technology incubators	**12**	**2.2**	**9**	**0.8**	**2**	**1.1**

3.3 Determinants of research utilisation: the results of bivariate analyses

In this section we look at the relationship between research utilisation and various aspects of the project. This involves a series of cross tabulations, with the question "Did the intended beneficiaries recognise/ utilise/ implement the research as planned?" as constant in all contingency tables. The results of the cross tabulations are displayed in Sections 3.3.1 to 3.3.8.

3.3.1 Sector of R&D performance

The sector of R&D performance, as measured by the institutional affiliation of the project leader, was the first variable to be cross-tabulated by the extent of research utilisation. Table 3.15 shows that science councils have the greatest extent of research utilisation, and technikons the lowest.

Table 3.15 Cross tabulation between research utilisation and the institutional classification of the project leader

Institutional classification	Did the intended beneficiaries recognise/ utilise/ implement the research as planned?				Number of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don't know	
Science councils	63.7	16.7	8.3	11.3	529
Universities	55.4	16.5	6.9	21.2	1050
Technikons	45.9	18.8	13.5	21.8	170

3.3.2 Motive or reason for the research

The second variable to consider as determinant of research utilisation was the motive or reason for the research (Table 3.16). Research utilisation is highest where the research has been conducted in response to an external request (a tender or contract from an outside company or funding agency). Also, greater uncertainty exists about the project's eventual utilisation in cases where the research was born out of own curiosity or interest.

Table 3.16 Cross tabulation between research utilisation and the motive or reason for the research

What triggered the research?	Did the intended beneficiaries recognise/ utilise/ implement the research as planned?				Number of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don't know	
An outside firm / company / institution approaching you	74.4	11.4	5.8	8.4	359
A tender / contract research	74.0	12.2	5.5	8.3	181
A funding agency requesting proposals	68.5	14.7	4.9	12.0	184
Previous research by yourself	62.0	15.8	5.9	16.2	727
Colleague(s) approaching you to form part of a team	60.9	14.4	8.4	16.3	417
Own interpretation of the immediate / future environment	59.7	21.2	6.7	12.4	466
Own curiosity or research interest	53.6	17.5	8.5	20.4	858

The general trend in Table 3.16 is clear and relates to the continuum of types of R&D, i.e. applied, strategic and fundamental research. Applied or application driven research, being short-term, is more likely to be utilised by the intended beneficiaries than fundamental research, which is mostly long-term. (Figure 3.5).

Figure 3.5 The relationship between types of R&D and research utilisation

Applied	Strategic	Fundamental
* An outside firm / company / institution approaching you * A tender / contract research	* A funding agency requesting proposals * Previous research by yourself * Colleague(s) approaching you to form part of a team * Own interpretation of the immediate / future environment	* Own curiosity or research interest
* Immediate / short-term * Solutions driven	* Medium-term	* Long-term * Curiosity driven

3.3.3 Broad research domain

As far as broad research domain is concerned, Table 3.17 shows that projects within the agricultural, environmental, engineering and biological sciences are more likely to be utilised. Against this, projects within arts and humanities, economic and management sciences, as well as the social and mathematical sciences, have the smallest probability of being utilised to some extent.

Table 3.17 Cross tabulation between research utilisation and broad research domain

Broad research domain	Did the intended beneficiaries recognise / utilise/ implement the research as planned?				Number of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don’t know	
Agricultural sciences	69.3	13.2	5.8	11.7	326
Environmental sciences	66.2	12.9	8.3	12.6	278
Engineering sciences	64.8	12.2	11.7	11.3	213
Biological sciences	64.6	15.8	6.7	12.8	297
Medical sciences: clinical	64.1	9.4	4.7	21.9	64
Earth sciences	63.6	19.7	5.3	11.4	132
Physical sciences	63.	7.9	7.9	21.1	76
Applied science and technologies	60.6	16.2	12.4	10.9	340
Information and communication technologies	59.6	16.3	12.1	12.1	141

Table 3.17 Continued

Broad research domain	Did the intended beneficiaries recognise / utilise/ implement the research as planned?				Number of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don't know	
Medical sciences: basic	58.7	15.2	6.5	19.6	92
Chemical sciences	58.5	13.0	12.2	16.3	123
Marine sciences	56.8	21.6	8.1	13.5	37
Health sciences	56.6	17.2	8.1	18.2	297
Material sciences	56.0	18.7	12.0	13.3	75
Arts and humanities	53.2	18.9	5.7	22.2	333
Economic and management sciences	53.1	20.6	7.0	19.3	243
Social sciences	52.9	21.9	8.3	16.9	433
Mathematical sciences	52.3	17.4	5.8	24.4	86

A possible explanation for the trend in Table 3.17 is that projects in the mathematical and socially oriented sciences are generally more likely to be triggered by own curiosity or research interest (Table 3.18).

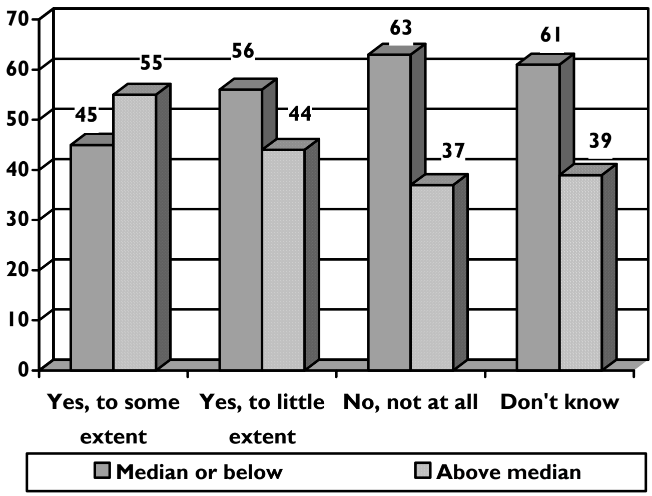
Table 3.18 Cross tabulation between selected research domains and motive or reason for the utilisation of research

Research domain	What triggered the research?			
	An outside firm/ company/ institution approaching you (A)	Own curiosity or research interest (B)	A and B	Not A or B
Greater utilisation				
Agricultural	23.1	28.3	9.4	39.2
Environmental	19.6	37.7	7.8	34.9
Engineering	27.2	27.6	8.8	36.4
Biological	19.7	39.0	9.0	32.3
Lesser utilisation				
Arts & humanities	5.8	60.3	4.9	29.0
Economic & management	13.2	50.8	4.4	31.6
Social	12.2	51.0	5.4	31.4
Mathematical	13.5	42.7	5.6	38.2

3.3.4 Research experience of project leader

The variable that measures the research experience of the project leaders was dichotomised by using the median years of experience within each sector as demarcation. Thus, for the science council sector the cut-off point were 13 years, and for universities and technikons 12 and 5 years respectively (see Table 3.2). The cross tabulation of research utilisation by years of research experience is shown in Figure 3.6.

Figure 3.6 Cross tabulation between research utilisation and years of research experience



In Figure 3.6 the research experience of the project leader is positively related to the utilisation of the project research: the greater the experience of the researcher, the greater the likelihood of eventual utilisation.

3.3.5 Time devoted to the project

We asked the project leaders approximately how much of their total working time they had devoted to the project during the course of the project (scale ranged from 10% to 100%). Cross tabulating their responses by research utilisation, the figures in Table 3.19 are derived.

Table 3.19 Cross tabulation between research utilisation and time spent on the project

Time spent on project	Did the intended beneficiaries recognise/ utilise/ implement the research as planned?				Number of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don't know	
Universities					
10-20%	**54.3**	**15.2**	**6.7**	**23.8**	**466**
30-40%	**56.2**	**20.3**	**6.1**	**17.4**	**345**
50%+	**56.8**	**13.1**	**8.5**	**21.6**	**236**
Technikons					
10-20%	**43.1**	**19.4**	**13.9**	**23.6**	**72**
30-40%	**44.8**	**20.9**	**16.4**	**17.9**	**67**
50%+	**56.7**	**10.0**	**6.7**	**26.7**	**30**
Science councils					
10-20%	**69.3**	**13.6**	**4.5**	**12.5**	**88**
30-40%	**64.4**	**15.6**	**7.4**	**12.6**	**135**
50%+	**62.7**	**17.7**	**9.3**	**10.3**	**300**

The amount of time spent on the project has its largest impact within the technikon sector: utilisation ("yes, to some extent") improves from 43% to 57% as time devoted to the project increases. Moreover, in the science council sector there is the interesting trend of declining utilisation as time spent on the project increases (from 69% to 63%).

3.3.6 Size of project funding

Size of project funding has emerged as a strong determinant of research utilisation, as is evident in Table 3.20. The general trend is that the higher the category of funding, the greater the possibility of the research being utilised to some extent. Similarly, smaller categories of funding are associated with greater uncertainty about the utilisation of the research.

Table 3.20 Cross tabulation between research utilisation and project funding

Funding	Did the intended beneficiaries recognise/ utilise/ implement the research as planned?				Number of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don't know	
Higher education					
Less than R50 000	**44.0**	**20.9**	**9.0**	**26.2**	**657**
R50 000 – R249 000	**63.8**	**13.0**	**7.2**	**15.9**	**276**
R250 000 or more	**74.9**	**12.8**	**5.2**	**7.1**	**211**
Science council sector					
Less than R250 000	**58.3**	**16.2**	**7.9**	**17.6**	**216**
R250 000 – R999 000	**65.1**	**18.6**	**9.3**	**7.0**	**172**
R1 000 000 or more	**70.8**	**15.4**	**6.5**	**7.3**	**123**

3.3.7 Project collaboration

Collaboration with others on the project is another strong determinant of the extent of research utilisation. If collaboration is present, the probability of a research project being utilised to some extent improves, on average, by about 23%. The largest impact of collaboration (28%) is recorded for the technikon sector (from 27.3% to 55.3%).

Table 3.21 Cross tabulation between research utilisation and collaboration on the project

Collaboration	Did the intended beneficiaries recognise/ utilise/ implement the research as planned?				Number of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don't know	
All sectors					
Yes	**62.5**	**16.0**	**6.3**	**15.2**	**1320**
No	**39.6**	**19.2**	**13.0**	**28.3**	**407**
Science councils					
Yes	**66.5**	**17.0**	**6.6**	**9.9**	**454**
No	**47.0**	**12.1**	**18.2**	**22.7**	**66**
Universities					
Yes	**61.2**	**15.0**	**5.6**	**18.2**	**752**
No	**40.2**	**20.6**	**10.1**	**29.0**	**286**
Technikons					
Yes	**55.3**	**18.4**	**9.6**	**16.7**	**114**
No	**27.3**	**20.0**	**21.8**	**30.9**	**55**

3.3.8 Intended beneficiaries of the research

The cross tabulation of research utilisation by the nature of the intended beneficiaries appears in Table 3.22. Research utilisation appears greater when the beneficiary is an entity with clear organisational boundaries, such as a specific agency, interest group or firm. This also implies that research utilisation is highest when the research is commissioned and there is a clear research contract.

Table 3.22 Cross tabulation between research utilisation and the intended beneficiaries of the project

Intended beneficiaries	Did the intended beneficiaries recognise/ utilise/ implement the research as planned?				Number of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don't know	
The contracting agency	**69.8**	**15.3**	**5.2**	**9.7**	**268**
Specific interest groups	**62.6**	**16.1**	**6.1**	**15.2**	**521**
Industry/ firms	**60.5**	**16.1**	**10.2**	**13.2**	**539**
General public/ society/ community	**57.4**	**17.4**	**7.2**	**18.0**	**545**
Government	**55.8**	**18.5**	**8.3**	**17.5**	**504**
Colleagues/ scholars/ peers: other disciplines	**55.1**	**19.2**	**6.1**	**19.6**	**459**
Colleagues/ scholars/ peers: own discipline	**54.9**	**18.4**	**5.8**	**20.9**	**1064**

3.4 Determinants of research utilisation: the results of multivariate analyses

In this section "research utilisation" was specified as a dependent variable and, together with a set of independent variables, submitted to a CHAID procedure. The purpose of CHAID (**Chi-**squared **A**utomatic **I**nteraction **D**etector) is to construct trees where each node identifies a split condition, to yield optimum classification for the categorical dependent variable. Differently put, CHAID visually displays models from which one can identify those groups that matter in the classification of research utilisation.

Three sets of CHAID analyses were performed: one for the higher education and science council sectors combined, and one for each sector on its own.

3.4.1 Science council and higher education sectors combined

For the combined analysis of CHAID the input variables were as follows:

Dependent variable

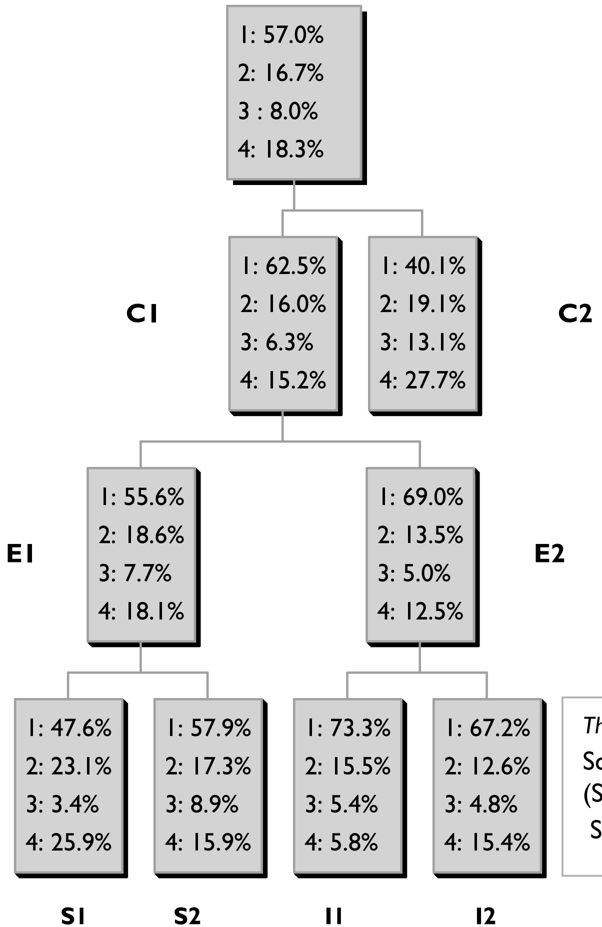
- Did the intended beneficiaries recognise/ utilise/ implement the research as planned? (1 = Yes, to some extent; 2 = Yes, to little extent; 3 = No, not at all; 4 = Don't know)

Independent variables

- Institution (1 = Science councils; 2 = Universities; 3 = Technikons)
- How long have you been involved in research? (1 = Median or below; 2 = Above median)
- Science culture of project activities (1 = Social sciences; 2 = Natural sciences; 3 = Health & medical sciences; 4 = Interdisciplinary social sciences; 5 = Natural and health & medical sciences combined)
- Did you collaborate with others on the project? (1 = Yes; 2 = No)
- Approximately how much of your total working time did you devote to this project during the course of the project? (1 = 10-20%; 2 = 30-40%; 3 = 50%+)

Figure 3.7 summarises the outcome of the CHAID analysis.

Figure 3.7 CHAID analysis based on all sectors



Dependent variable
Did the intended beneficiaries recognise/ utilise/ implement the research as planned?

First level independent variable
Did you collaborate with others on the project?
(C1 = Yes; C2 = No)

Second level independent variable
How long have you been involved in research?
(E1 = Median or below; E2 = Above median)

Third level independent variable
Science culture
(S1 = Social sciences;
S2 = All the others combined)

Third level independent variable
Institutional classification
(I1 = Science councils;
I2 = Universities & technikons)

As can be seen in Figure 3.7, collaboration is the single most important determinant of research utilisation: 62.5% of all projects with collaboration have been recognised/ utilised/ implemented to some extent by the intended beneficiaries, compared to 40.1% of projects with no collaboration.

The second most important predictor is the research experience of the project leader. The percentage of projects utilised to some extent drops from 62.5% to 55.6% if the project leader has less than the median years of research experience. If the project leader has more than the median years of experience, utilisation improves to 69%.

Two independent variables feature on the third level of the CHAID outcome. The first, the science culture classification of the project activities, impacts only on cases where there is collaboration and the project leader has limited research experience. Under these circumstances, research utilisation will drop from 55.6% to 47.6% if the collaboration is within the social sciences only. The second independent variable on this level relates to projects where there is collaboration and the research project leader has significant research experience. Here research utilisation will improve from 69% to 73.3% if the project is housed at a science council.

The result of the CHAID was further explored through various cross tabulations, especially with institutional classification, sector of collaboration and the science culture of the project. These breakdowns are only for projects that have been utilised to some extent.

Table 3.23 Breakdown by institutional classification and sector of collaboration (projects with collaboration)

Collaborated with	Higher Education sector		Science council sector		Total	
	%	N	%	N	%	N
NGOs	**77.0**	**87**	**73.9**	**69**	**75.6**	**156**
Industry/ business	**70.0**	**200**	**68.9**	**206**	**69.5**	**406**
Science council(s)	**65.4**	**52**	**69.9**	**176**	**68.9**	**228**
Government	**64.2**	**137**	**68.6**	**140**	**66.4**	**277**
Academics/ scholars	**60.6**	**749**	**68.0**	**294**	**62.7**	**1043**

The breakdown of utilisation (operationalised by the response "Yes – to some extent") by sector of collaboration shows that projects with an NGO as collaborator are more likely to be utilised. Of 156 projects with an NGO as collaborator almost 76% of projects have been utilised to some extent by the intended beneficiaries.

Research projects involving collaboration with industry/business have the second highest likelihood of utilisation in the higher education sector (70%). In the science council sector, collaboration with other science councils assumes the second place (69.9%).

Table 3.24 gives a further breakdown of Table 3.23, by also incorporating years of research experience (above or below the median – see Section 3.2.3).

Table 3.24 Breakdown by institutional classification and years involved in research (projects with collaboration, per sector of collaboration)

Years involved in research	**Higher Education sector**		**Science council sector**		**Total**	
	%	N	%	N	%	N
Academics/ scholars						
Median or below	53.2	344	62.3	162	56.1	506
Above median	66.8	400	75.8	128	68.9	528
Government						
Median or below	61.1	54	66.7	75	64.3	129
Above median	66.3	83	70.8	65	68.2	148
Science council(s)						
Median or below	58.8	17	63.6	88	62.9	105
Above median	68.6	35	76.1	88	74.0	123
NGOs						
Median or below	62.2	37	70.7	41	66.7	78
Above median	88.0	50	78.6	28	84.6	78
Industry/ business						
Median or below	57.3	75	61.2	116	59.7	191
Above median	77.6	125	78.7	89	78.0	214

The research experience of the primary researcher is crucial for utilisation, especially when collaborating with NGOs and industry/business, and even more so when the primary researcher is employed within higher education. For instance, if the project leader's research experience is less than that of the median for his/her sector, only 62.2% of HES projects with collaboration in the NGO sector seem to be utilised to some extent. This increases drastically to 88% for researchers with above average research experience.

Tables 3.25 and 3.26 differ from Tables 3.23 and 3.24 in that the sector of collaboration has been replaced by the science culture of the project activities.

Table 3.25 Breakdown by institutional classification and science culture (projects with collaboration)

Science culture	Higher Education sector		Science council sector		Total	
	%	N	%	N	%	N
Interdisciplinary social sciences	**64.9**	**131**	**68.1**	**72**	**66.0**	**203**
Natural and health & medical sciences	**64.4**	**59**	**68.8**	**32**	**65.9**	**91**
Natural sciences	**63.1**	**295**	**66.8**	**310**	**65.0**	**605**
Social sciences	**56.9**	**283**	**59.1**	**22**	**57.0**	**305**
Health & medical sciences	**53.1**	**96**	**64.7**	**17**	**54.9**	**113**

Projects of a more interdisciplinary nature (interdisciplinary social sciences, and a combination of natural and health and medical sciences) are more likely to be utilised than those associated with a single science culture (especially social sciences). This applies to both higher education and science council projects (Table 3.25).

Table 3.26 Breakdown by institutional classification and years involved in research (projects with collaboration, per science culture)

Science culture	Higher Education sector		Science council sector		Total	
	%	N	%	N	%	N
Social sciences						
Median or below	**48.1**	**135**	**41.7**	**12**	**47.6**	**147**
Above median	**64.9**	**148**	**80.0**	**10**	**65.8**	**158**
Natural sciences						
Median or below	**57.1**	**126**	**61.7**	**167**	**59.7**	**293**
Above median	**66.9**	**166**	**73.6**	**140**	**69.9**	**306**
Health & medical sciences						
Median or below	**48.0**	**50**	**60.0**	**10**	**50.0**	**60**
Above median	**57.8**	**45**	**71.4**	**7**	**59.6**	**52**
Interdisciplinary social sciences						
Median or below	**57.1**	**63**	**64.3**	**42**	**60.0**	**105**
Above median	**73.1**	**67**	**72.4**	**29**	**72.9**	**96**
Natural and health & medical sciences						
Median or below	**41.2**	**17**	**62.5**	**16**	**51.5**	**33**
Above median	**73.8**	**42**	**75.0**	**16**	**74.1**	**58**

In Table 3.26 the research experience of the primary researcher makes the largest difference in the utilisation of (a) projects in the social sciences within the science council sector (utilisation increased from 41.7% to 80%) and (b) interdisciplinary projects in the natural and medical and health sciences within the higher education sector (utilisation increased from 41.2% to 73.8%). These findings, however, should be interpreted with circumspection, given the small number of projects on which the observations are based.

3.4.2 Science council sector

The following variables served as input to the CHAID analysis for the science council sector:

Dependent variable

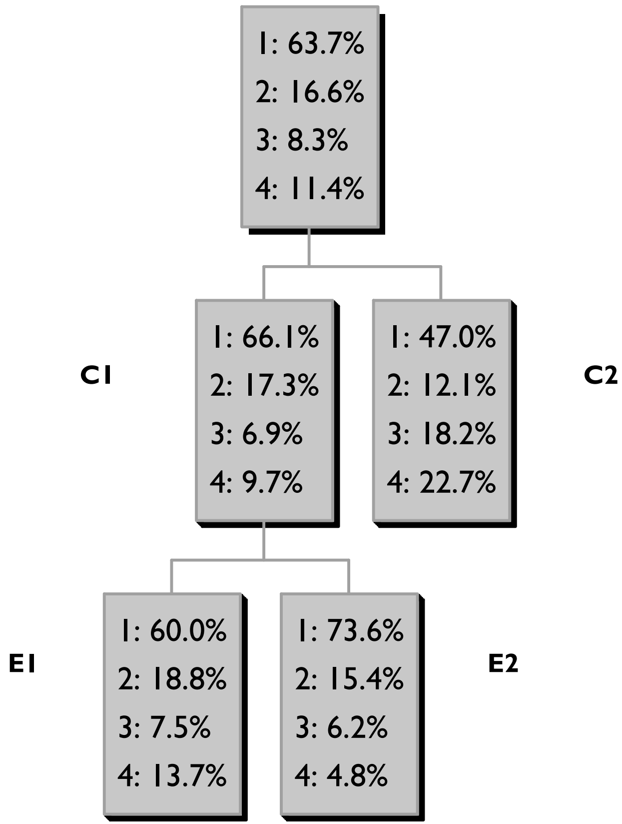
- Did the intended beneficiaries recognise/ utilise/ implement the research as planned? (1 = Yes, to some extent; 2 = Yes, to little extent; 3 = No, not at all; 4 = Don't know)

Independent variables

- How long have you been involved in research? (1 = Median or below; 2 = Above median)
- Science culture of project activities (1 = Social sciences; 2 = Natural sciences; 3 = Health & medical sciences; 4 = Interdisciplinary social sciences; 5 = Natural and health & medical sciences)
- How much funding did you have for the project in total? (1 = Less than R250 000; 2 = R250 000 to R999 000; 3 = R1 000 000 or more)
- Did you collaborate with others on the project? (1 = Yes; 2 = No)
- Approximately how much of your total working time did you devote to this project during the course of the project? (1 = 10-20%; 2 = 30-40%; 3 = 50%+)

The outcome of the CHAID analysis for science councils is shown in Figure 3.8. This almost replicates that of the combined analysis (Figure 3.7) as far as the first two levels of independent variables are concerned. Again collaboration seems to be the most important predictor of research utilisation, followed by the research experience of the project leader (66.1% of projects with collaboration have been utilised to some extent by the intended beneficiaries, which increases to 73.6% if the project leader's research experience surpasses the median for his/her sector of employment).

Figure 3.8 **CHAID analysis for the science council sector**



Dependent variable
Did the intended beneficiaries recognise / utilise / implement the research as planned?

First level independent variable
Did you collaborate with others on the project?
(C1 = Yes; C2 = No)

Second level independent variable
How long have you been involved in research?
(E1 = Median or below; E2 = Above median)

Table 3.27 gives a breakdown of science council projects by sector of collaboration and years of research experience, based on the number of projects that have been utilised to some extent.

Table 3.27 Breakdown by sector of collaboration and years of experience (science council projects with collaboration)

Collaborated with	Research experience Median or below		Research experience Above the median		Total	
	%	N	%	N	%	N
NGOs	**70.7**	**41**	**78.6**	**28**	**73.9**	**69**
Science council(s)	**63.6**	**88**	**76.1**	**88**	**69.9**	**176**
Industry/ business	**61.2**	**116**	**78.7**	**89**	**68.9**	**206**
Government	**66.7**	**75**	**70.8**	**65**	**68.6**	**140**
Academics/ scholars	**62.3**	**162**	**75.8**	**128**	**68.0**	**294**

For more experienced researchers, projects conducted in collaboration with government are less likely to be utilised (70.8%) compared to projects conducted in collaboration with industry/business (78.7%) and NGOs (78.6%). For less experienced researchers, projects conducted in collaboration with NGOs have the best chance of being utilised (70.7%).

3.4.3 Higher education sector

The input variables for the CHAID analysis based on the higher education data are as follows:

Dependent variable

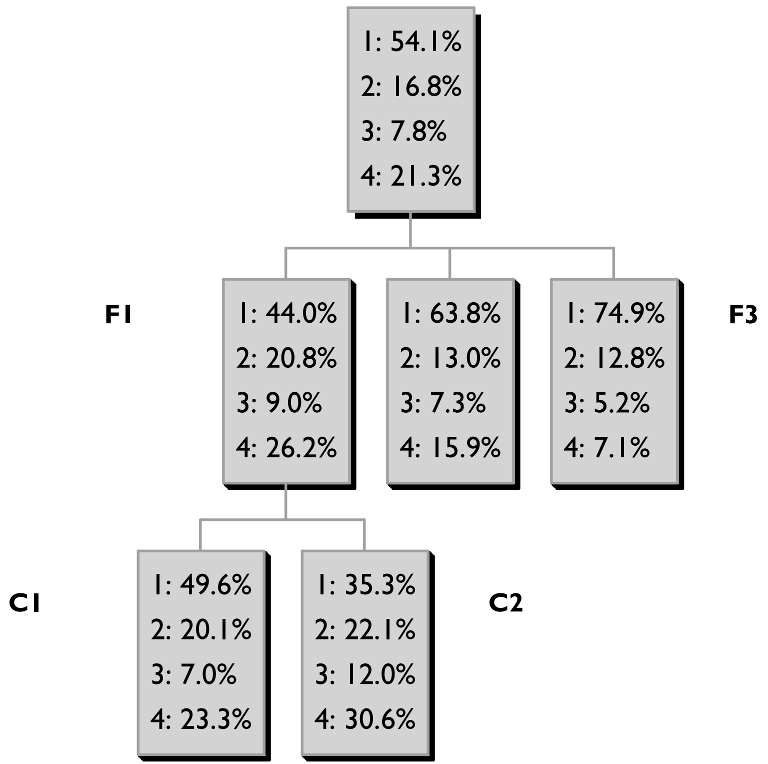
- Did the intended beneficiaries recognise/ utilise/ implement the research as planned? (1 = Yes, to some extent; 2 = Yes, to little extent; 3 = No, not at all; 4 = Don't know)

Independent variables

- How long have you been involved in research? (1 = Median or below; 2 = Above median)
- Science culture of project activities (1 = Social sciences; 2 = Natural sciences; 3 = Health & medical sciences; 4 = Interdisciplinary social sciences; 5 = Natural and health & medical sciences)
- How much funding did you have for the project in total? (1 = Less than R50 000; 2 = R50 000 to R249 000; 3 = R500 000 or more)
- Did you collaborate with others on the project? (1 = Yes; 2 = No)
- Approximately how much of your total working time did you devote to this project during the course of the project? (1 = 10-20%; 2 = 30-40%; 3 = 50%+)

The outcome of the CHAID appears in Figure 3.9.

Figure 3.9 **CHAID analysis for the higher education sector**



Dependent variable
Did the intended beneficiaries recognise/ utilise/ implement the research as planned?

First level independent variable
How much funding did you have for the project in total?
(F1 = Less than R50 000;
F2 = R50 000 to R249 000;
F3 = R500 000 or more)

Second level independent variable
Did you collaborate with others on the project?
(C1 = Yes; C2 = No)

In Figure 3.9 the size of the project funding is the single most important predictor of research utilisation in the higher education sector: the higher the total amount of funding procured, the greater the utilisation of the research outcome (75% utilisation when funding is more than R250 000). Collaboration has entered the analysis as a second level independent variable, for projects where the funding is less than R50 000.

Below are breakdowns by sector of collaboration (Table 3.28) and science culture (Table 3.29), based on the number of projects that have been utilised to some extent.

Table 3.28 Breakdown by sector of collaboration and project funding (higher education projects with collaboration)

Collaborated with	Less than R50 000		R50 000 – R249 000		R250 000+	
	%	N	%	N	%	N
Academics/ scholars	**50.9**	**336**	**64.5**	**211**	**75.4**	**179**
Government	**45.8**	**48**	**58.8**	**34**	**84.0**	**50**
Science council(s)	**62.5**	**16**	**76.9**	**13**	**59.1**	**22**
NGOs	**70.0**	**30**	**72.2**	**18**	**83.3**	**36**
Industry/ business	**49.2**	**63**	**75.5**	**53**	**81.5**	**81**

In Figure 3.9, when funding is highest (R250 000 +) no other predictor could significantly better the research utilisation. But if we cross-tabulate the projects in this funding category by sector of collaboration, it is predominantly projects with collaboration in government, NGOs and business/industry that seem to be more utilised. Collaboration with science councils appears least important for utilisation when funding is optimal (Table 3.28).

According to Table 3.29 large-scale projects (in terms of funding, i.e. R250 000+) have a greater chance of being utilised when the project is of an interdisciplinary nature. The same applies to small-sized projects (where funding is less than R50 000).

Table 3.29 Breakdown by science culture and project funding (higher education projects with collaboration)

Science culture	Less than R50 000		R50 000 – R249 000		R250 000+	
	%	N	%	N	%	N
Social sciences	**42.2**	**327**	**67.4**	**86**	**69.8**	**43**
Natural sciences	**43.0**	**135**	**61.0**	**100**	**74.5**	**106**
Health & medical sciences	**41.3**	**63**	**61.9**	**21**	**76.5**	**17**
Interdisciplinary social sciences	**50.5**	**105**	**59.5**	**42**	**79.3**	**29**
Natural and health & medical sciences	**53.8**	**26**	**69.2**	**26**	**80.0**	**15**

3.4.4 Selected clusters of research domain

As a matter of interest, and to investigate the robustness of collaboration as a determinant of research utilisation, we have conducted three more CHAIDs for selected combinations of research domain:[3]

- Arts and humanities, economic and management sciences, and social sciences combined
- Engineering sciences and applied sciences and technologies combined
- Agricultural and environmental sciences combined

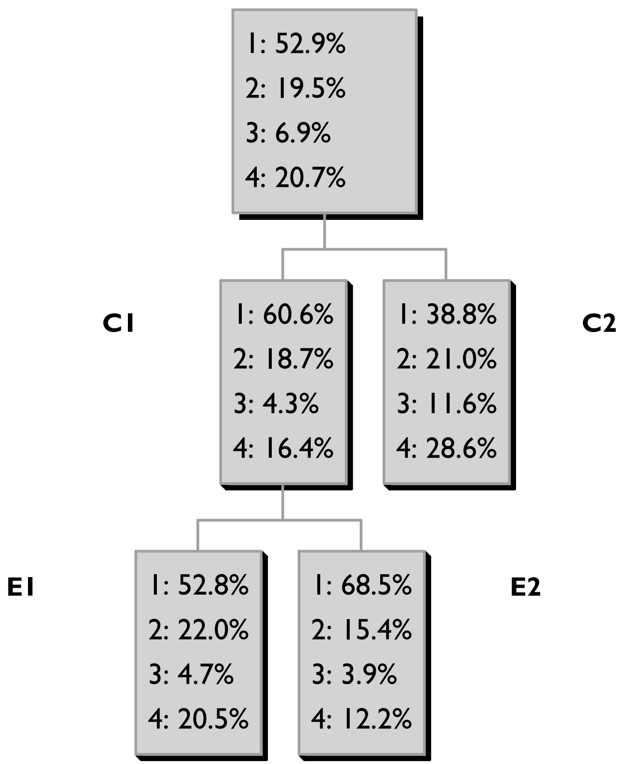
The following served as independent variables:

- Institution (1 = Science councils; 2 = Universities; 3 = Technikons)
- How long have you been involved in research? (1 = Median or below; 2 = Above median)
- Did you collaborate with others on the project? (1 = Yes; 2 = No)
- Approximately how much of your total working time did you devote to this project during the course of the project? (1 = 10-20%; 2 = 30-40%; 3 = 50%+)

Results are shown in Figures 3.10 to 3.12. For two of the three CHAIDs collaboration again emerged as the strongest determinant of research utilisation. The exception is agricultural and environmental sciences where institutional affiliation provided the best classification.

[3] Meaningful clusters were required to ensure a minimum of 500 projects per CHAID analysis.

Figure 3.10 **CHAID analysis for the social sciences, arts and humanities, and economic and management sciences combined**

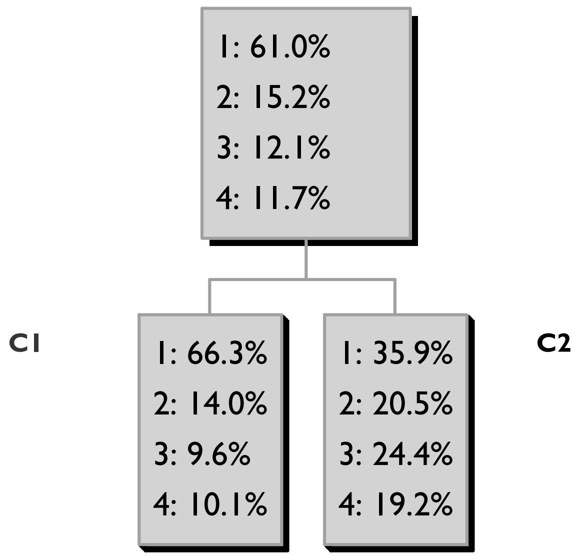


Dependent variable
Did the intended beneficiaries recognise/ utilise/ implement the research as planned?

First level independent variable
Did you collaborate with others on the project?
(C1 = Yes; C2 = No)

Second level independent variable
How long have you been involved in research?
(E1 = Median or below; E2 = Above median)

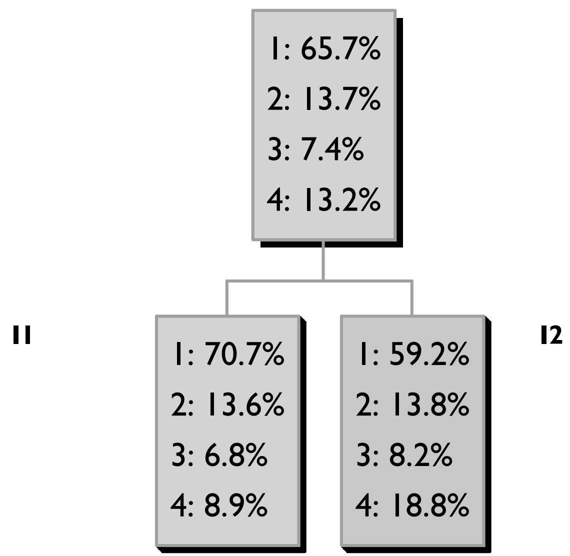
Figure 3.11 CHAID analysis for engineering sciences and applied science and technologies combined



Dependent variable
Did the intended beneficiaries recognise/ utilise/ implement the research as planned?

First level independent variable
Did you collaborate with others on the project? (C1 = Yes; C2 = No)

Figure 3.12 CHAID analysis for agricultural and environmental sciences combined



Dependent variable
Did the intended beneficiaries recognise/ utilise/ implement the research as planned?

First level independent variable
Institutional classification
(I1 = Science councils;
I2 = Universities & technikons)

The results of the three CHAID-analyses showed quite marked differences between the three domains. In the case of the social sciences and humanities, whether collaboration occurred or not emerged as the most important predictor, followed by the differences in the research experience of the project leader (Table 3.30). Whether collaboration took place or not was the only significant correlate in the case of the engineering and applied technological sciences. Where collaboration was reported, effective utilisation was reported for 66% of the projects; where there was no collaboration reported, the percentage of reported utilisation of research findings dropped to 36% (Figure 3.11).

Table 3.30: Predictors of effective utilisation in the case of the social sciences and humanities

Predictor	% effective utilisation	N of projects
Collaboration with other researchers and above average research experience of project leader	**68.5%**	**254**
Collaboration with other researchers and below average research experience of project leader	**52.8%**	**254**
No collaboration with other researchers/projects	**38.8%**	**276**

As far as the agricultural and environmental sciences are concerned, the institutional sector (science councils vs. higher education sector) turned out to be the only significant correlate. Research projects being undertaken within the science council sector (predominantly within the Agricultural Research Council) was reported has being effectively utilised in 71% of the cases, whereas for the universities and technikons this percentage was a much lower 59%.

CHAPTER 4
CONCLUSIONS

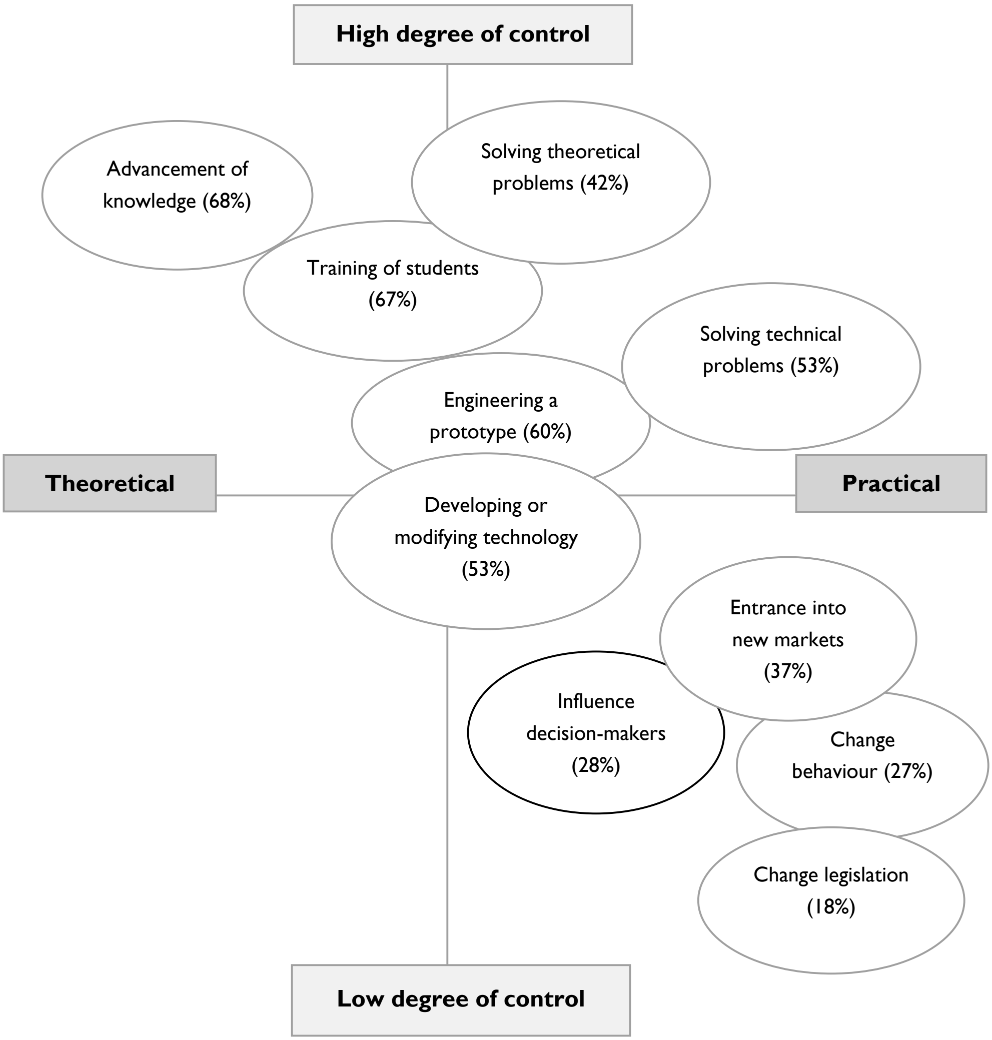
The salient results, which have emerged from the questionnaire survey, can be summarised in the form of five key propositions:

PROPOSITION 1 The utilisation of research takes on a variety of forms ranging from the advancement of knowledge to changing human behaviour, developing new technologies and solving applied problems. All forms of utilisation are evident in the research projects described in this study.

The most highly cited expected outcomes from research (advancement of knowledge, skills development, research capacity building) all refer to outcomes that are to some extent within the control of the researcher (Table 3.9). Those outcomes that are less under the control of the researcher, such as changing human behaviour, informing legislation and entrance into new markets, were reported as occurring with lower probabilities than the first category. More theoretical outcomes (advancing knowledge) were rated as being more likely to occur than more practical outcomes (solving applied problems).

These results can be used to develop a typology that plots the various expected outcomes along two dimensions: the degree of control and theory-practice continuum (Figure 4.1). The interesting and crucial point about research utilisation that is made more explicit by this two-dimensional plotting of the responses, is that the utilisation of research is a function not only of the nature of the expected outcome of the R&D process, but also the degree of control over the further path or trajectory of the outcomes of the R&D process.

Figure 4.1: Two-dimensional plotting of outcomes of R&D process



As far as the theory-practice dimension is concerned, we have to remind ourselves that scientific research or inquiry typically produces research outputs of two kinds: 'epistemic' or 'knowledge' outputs and 'non-epistemic' outputs or knowledge applications (Bailey and Mouton, 2005). Epistemic outputs include all forms of new knowledge: new theories, interpretations, insights, models, hypotheses, conjectures, facts, data as well as instrumentation. Epistemic outputs (or 'new knowledge') in turn, can be divided into *codified* or *embedded* (or 'tacit') knowledge. Codified knowledge is knowledge that has been 'written up' and which is usually transmitted to a particular audience in a standard form such as a scientific presentation, paper, book, report, electronic communication and so on. Embedded knowledge refers to the knowledge (including skills, competencies) that is embedded in people.

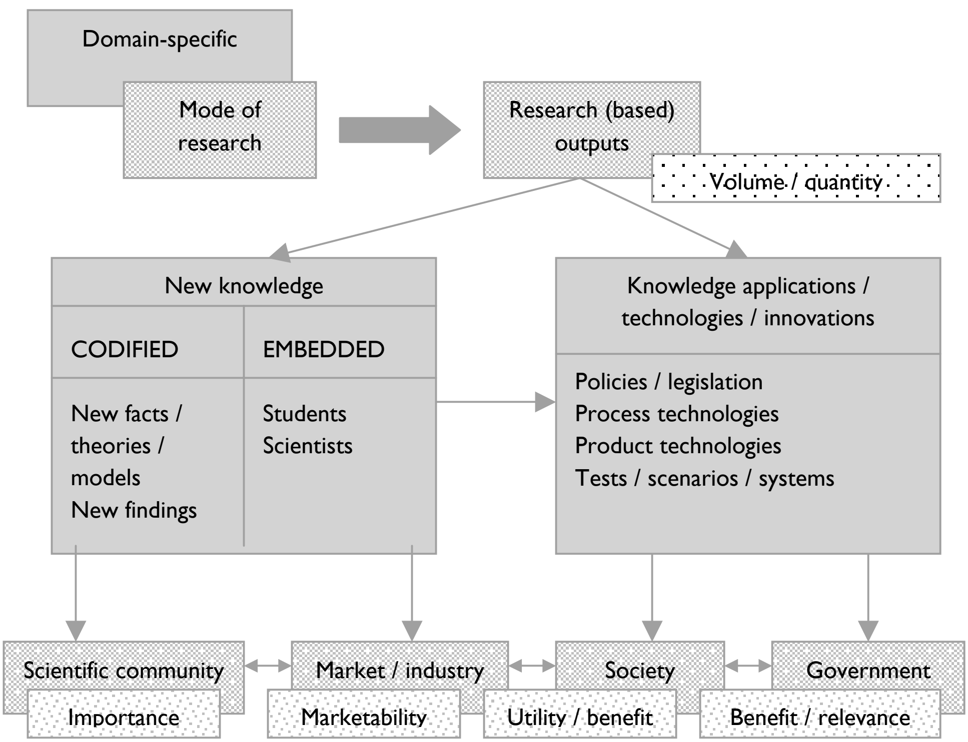
Non-epistemic outputs include all forms of application and technology that flow from the research process. These include process and product technologies and artefacts as well as social science applications such as policies, programmes, interventions, tests, scenarios, strategies, plans, systems, and many more.

These distinctions are incorporated into a heuristic framework (Figure 4.2 below) on the relationship between modes of knowledge production and utilisation.

Different modes of knowledge production clearly have different intended or unintended audiences (or target groups, beneficiaries, user groups) in mind. We expand this principle in the framework by including the most important audiences of research: the scientific community, the market/industry, society and government.

And finally, we introduce in the framework reference to the various properties of research (outputs): volume or quantity, quality or merit, importance, marketability, utility or benefit and relevance. These six properties are often encountered in R&D evaluation studies where the focus is on evaluating or assessing research in terms of one or more of its properties. So, for instance, we might wish to assess the volume of research output of an individual scientist or centre over time. Or we might be interested in comparing the quality or merit of different scientists for purposes of promotion or funding through peer review.

Figure 4.2 A framework of the production and utilisation of knowledge



If we relate the results of our survey to the framework above, it becomes clearer why the reported expected outcomes of research vary across the two dimensions identified. What we termed the "theoretical outcomes" (advancement of knowledge, skills development and – to some extent – research capacity building") refer to epistemic outputs. The more practical outcomes (development of new technology, modification of existing technology, changing behaviour, informing policy and legislation) are all examples of "knowledge applications".

The value of the survey results is that it has alerted us to the importance of the second dimension: the degree of control over research outputs. Some outcomes of research – such as solving theoretical problems or adding to our knowledge of the world – are more clearly within the control of the researcher. Other outcomes are much more clearly outside of the control of the researcher – entrance into new markets, changing human behaviour and informing legislation.

Another way of explaining these results is to propose a distinction between factors *internal* to the R&D process (those within the control of the researcher) and those *external* to the research process (e.g. market forces, political dynamics, the vagaries of human behaviour, cost of utilisation, etc.). The obvious value of this distinction is that it would impact on strategies for promoting research utilisation: strategies that aim to increase theoretical/epistemic outputs will differ from those aimed at increasing the utilisation of knowledge applications.

PROPOSITION 2 How one interprets the extent of research utilisation depends on one's definition of "utilisation". If one accepts a broad definition, the survey results suggest fairly significant levels of successful utilisation. If one takes a more limited definition as the point of departure, the survey results paint a much bleaker picture of low levels of research utilisation.

In our review of the literature, we made the following distinction: The term 'research utilisation' can be understood either in a *narrow* or *broad* sense. In the narrow sense, the utilisation of research refers to the economic or commercial utility of research, i.e. how science is useful for economic growth or commercial aims. In the broader sense, research utilisation refers to any form of use that scientific research (results) is put to. So, in addition to economic or commercial utility, we could also include social utility (use of research for society at large) and political utility (science in support for political decision-making). We will refer to these as non-epistemic forms of utilisation.

But even this broadening of the meaning does not cover all possible forms of research use. We also need to remind ourselves that science (at least 'basic' or 'fundamental' science) is first and foremost aimed at the advancement of knowledge and increasing our understanding of the world. Some would argue that no use is intended or anticipated within a fundamental science paradigm. This is only true if 'use' is reserved for the narrow meaning of 'economic' or 'applied' use. But other scientists of course, use fundamental science. One scientist 'uses' another's findings or uses a model or framework developed by another. We often talk about 'applying' the insights gained in one study to another. We will refer to this as the epistemic utility of scientific research: research for the sake of (producing) knowledge.

Based on this distinction, we can group the various expected outcomes listed by project leaders into three groups (Cf. Table 1 below) viz. *epistemic* utility (mainly knowledge products/outputs), *economic* utility (new technologies and commercial products) and *social* utility (social benefits). We should also remind ourselves that epistemic utility comprises both codified and tacit or embedded knowledge products.

Table 4.1: Expected research outcomes classified as 'epistemic', 'economic' and 'social' utility

Epistemic utility (knowledge)	Economic utility	Social or political utility
Advancement of knowledge	Solving technical or applied problems	Solving social/environmental problems
Solving theoretical problems	Development of a new technology	Influencing decision-makers
Skills development	Engineering a prototype	Changing behaviour
Training of students	Modification of existing products and designs	Changing legislation
	Entrance into new markets	

The responses to two questions posed in the survey allow us to estimate, to some degree, the extent or scope of research being utilised. Respondents were first asked to list the most likely outcomes that would be produced by their research. These responses, ranked in descending order, were reported in Table 3.8. In a follow-up question, respondents were asked to indicate whether they believed the outcome had been successfully attained. Three options were given: highly successful, successful to some extent, and not successful at all. By combining the responses to these two questions, we are able to estimate what proportion of research leads to the successful achievement of the expected outcomes. So, for example, 70% of respondents indicated that one of the expected outcomes of their research is the advancement of knowledge. In the follow-up question, a similar percentage (68%) of respondents indicated that they believed that their research was *highly* successful in achieving this outcome. This means, in effect, that 48% (70% of 68 respondents) of all research reported on, was estimated to have been highly successful in leading to the advancement of knowledge. In this case, a further 30% indicated that they believe that their research was *to some extent* successful in achieving this outcome. Table 4.2 presents the findings of these two combined questions (reporting on the "highly successful attainment" and "successful to some extent" options) for all expected outcomes. The results are categorised according to the three main categories of research utility.

Table 4.2: Successful research utilisation

Epistemic utility (knowledge)	% successful	Economic utility	% successful	Social or political utility	% successful
Advancement of knowledge	69%	Solving of technical or applied problems	24%	Solving social and environmental problems	20%
Solving theoretical problems	13%	Development of a new technology	14%	Influencing decision-makers	19%
Skills development	32%	Modification of existing products and designs	8%	Changing behaviour	17%
Training of students	29%	Engineering a prototype	3%	Changing legislation	3%
		Entrance into new markets	3%		

PROPOSITION 3 Reported effective utilisation of research is clearly related to the type of R&D concerned.

In our development of a heuristic framework to assist in the explanation of factors influencing research utilisation (Bailey and Mouton 2005), we formulated the following proposition: Forms of research utilisation are strongly influenced by the nature of the research/mode of knowledge production (research modes / modes of knowledge production).

Applying the standard Frascati distinction between basic fundamental, basic strategic and applied research, we elaborated on these distinctions further. The results are summarised in Table 4.3.

Table 4.3: On modes of knowledge production

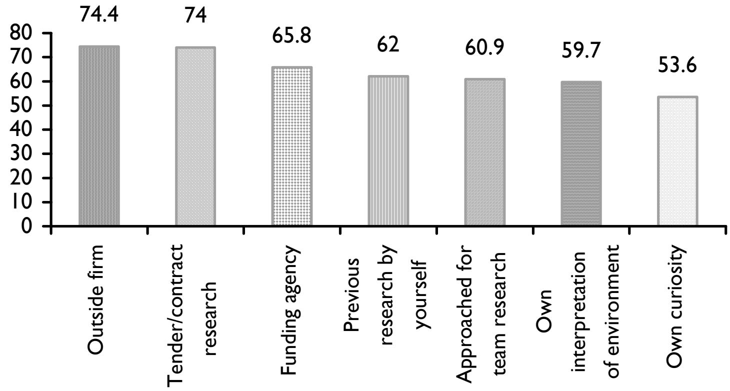
Mode	Motive	Timeframe	Audience	Funding source	Dissemination	Quality control
Fundamental	Curiosity	Indefinite	World of science	Scarce Own institution Public funding	Scientific publications/ Presentations	Peer review
Strategic	Curiosity + Utility	Long-term	World of science and other as yet unidentified beneficiaries	Public funding Other sources	Scientific forms	Peer review/ Potential users
Applied	Utility	Short- to medium-term	Specific users/ beneficiaries	Private funding	Confidential contract reports/ strategic briefings	User satisfaction

It is important to realize that the mode of research already 'pre-determines' or at least 'influences' the following:

- The *form* and channels of dissemination
- The perceived *value* of the research output (scientific/social/economic)
- The intended *target audience* or beneficiaries of the research output(s).

The relationship between "modes of knowledge production" or "type of R&D" and reported utilisation of research is clearly demonstrated in Figure 4.3 below when the motive behind the research and reported utilisation are cross-tabulated. Higher reported utilisation is evidently related to those "triggers" of research that concern commissions from outside firms or companies or contracted research. At the other end of the scale, we find that research that is driven more by curiosity has lower levels of reported utilisation.

Figure 4.2: Triggers of research and effective utilisation



PROPOSITION 4 The multivariate analysis has unequivocally shown that the utilisation of research/knowledge is correlated highly with four key factors. These are whether there is evidence of research collaboration in the project and with whom there is collaboration; the research experience of the project leader and the size of the project as measured in the amount of project funding.

The fact that these four factors correlate highly with "reported" effective utilisation does, of course, not imply any causal relationship. However, it does force us to investigate further the possible reasons that could explain these correlations.

Collaboration means increased access to scientific resources: more funding, more extensive research networks, the potential utility of a larger pool of stakeholders, and so on. The fact that project leaders have reported a much higher likelihood of effective utilisation when there has been a history of collaboration in the project might be interpreted to mean that effective utilisation is more likely to occur when the project has access to intellectual and social resources such as these.

Equally important is the "locality" of those that one collaborates with. Collaborating with other scholars in one's own sector is important but does not necessarily results in access to new resources – only to more of the same. But collaboration with scientists and non-scientists in other sectors of the national innovation system – such as government, industry and NGOs – does imply possible access to new resources – new sources of funding, new networks and communities. It is, therefore, not surprising that reported utilisation is higher when collaboration is across sectors and outside of R&D institutions.

The fact that the research experience of the project leader has emerged as a significant predictor of effective utilisation is compatible with the collaboration factors. But it raises additional points. Experienced researchers not only have more extensive networks (the point about collaboration), but it also suggests better project management skills and better utilisation of the available research resources. Both of these factors could enhance the likelihood of research utilisation.

And finally, the size of the project – as measured in terms of project funding – was significantly correlated with successful utilisation. Again, this suggests that larger projects, which have access to more resources (more researchers/ equipment/ infrastructure/ more intellectual capital in the form of networks), are more likely to lead to effective utilisation.

In conclusion: effective utilisation, to the extent that it is within the control of the project leader (or team), is more likely to occur where researchers collaborate – especially across R&D institutions and sectors, where there are experienced project leaders in charge of such projects and where there is a critical mass of resources (including funding) available to the team.

PROPOSITION 5 The effective utilisation of R&D does occur differently across different scientific domains and within different institutional settings.

The results with regard to main scientific domain, presented in Table 3.17, show a wide range of reported utilisation: from nearly 70% in the case of the agricultural sciences to just above 50% for the mathematical sciences. Cross tabulations with motives of research have shown that these results can be explained to some extent by the fact that those scientific domains which reported lower expected utilisation (mathematics and social sciences) are also more highly correlated with more fundamental research interests (e.g. own curiosity).

In order to assess how different predictor variables are related to reported effective utilisation for different science domains, we conducted separate CHAID-analyses for the humanities and social sciences, the engineering and applied technological sciences, and the agricultural and environmental sciences. The results for these three broad science domains (Section 3.4.4) are important because they suggest that institutional context is another important factor in understanding the dynamics that underpin the effective utilisation of research findings. The fact that research being undertaken within the science council sector (as graphically illustrated by the example of the agricultural sciences) generally reported higher utilisation, is yet another indication that the nature of R&D conducted – which is also correlated with science domain – is a strong predictor of whether utilisation takes place or not.

Despite the increasing blurring of boundaries between the science councils and higher education institutions, it is still fair to say that more applied and applications-driven research occurs within the science councils. In terms of the Bozeman model: the demand environment that influences R&D within science councils places a higher premium on applied and commissioned research that will produce results. Conversely, although there has been a noticeable shift towards applied and Mode 2 forms of research within South African universities and technikons over the past decade, it is still the case that basic fundamental and curiosity-driven research is found more within these institutions than anywhere else.

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Appendix A

Questionnaire: Higher Education Sector

**PUBLIC SECTOR R&D IN SOUTH AFRICA:
THE PRODUCTION AND UTILISATION OF RESEARCH**

A. YOUR BACKGROUND

1. Title: ..…………………….

2. Surname: ………………………………..…………………………………………………….

3. First names: …………………………………..……………………………………………

4. Institution: …………………...……………………………………………………………..

5. Department/Centre/Division/Institute: ……………..…………………...……………………

6. Position (e.g. senior lecturer): ……………………...………………...…..…...………………..

7. How long have you been at your current institution? …………………………………………

8. Have you ever spent time in government or industry?

	Yes	No
Government	1	2
Industry	1	2

If yes, for how many years?
………………. (yrs)
………………. (yrs)

9. Highest educational qualification completed: ………………………………………………

10. Gender:

Female	1
Male	2

11. Year of birth: 19…………

Please reflect on your research activities of the past five years (1997 to 2001). Think about your core research project **that you are involved in. The project may be a recently completed one or still ongoing, but you must be the** primary/principal investigator or project leader**. Section B applies to this project that you select.**

B. CORE RESEARCH PROJECT

12. Title: ………...………………...…………………………………………………………...………….
……………...……………………………………………...………………...…………………….
……………...……………………………………………...………………...…………………….

13. Please give a brief description of the research topic (e.g. the quantification of resistances to blood flow in the lower limb arterial system using an inverse transmission line model; current trends in the selection of students for Higher Education, etc.)
……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
……………………………………………………………………………………………………..

14. In which broad research domain(s) do the research activities mainly fall? (Tick all that apply.)

Agricultural sciences	1
Applied sciences and technologies	2
Biological sciences	3
Chemical sciences	4
Earth sciences	5
Engineering sciences	6
Environmental sciences	7
Humanities	8
Information, computer and applied technologies	9
Marine sciences	10
Material sciences	11
Mathematical sciences	12
Medical and health sciences	13
Physical sciences	14
Social sciences	15

15. What triggered the research? (Tick all that apply.)

Previous research by yourself	1
Own curiosity	2
Colleague(s) approaching you to form part of a team	3
An outside firm/company/institution approaching you for assistance	4
Own interpretation of the immediate environment	5
A funding agency requesting a proposal	6
A tender	7
Other (Specify: ………………………………………………………………)	8

16. (a) What year did the programme start? ……....…… (year)

(b) What year did/will it end? ……....…… (year)

17. (a) How much funding (grants, awards, contracts) do you have for the project in total (up to the end of 2001)?

Less than R10 000	1
R10 000 – R49 000	2
R50 000 – R99 000	3
R100 000 – R199 000	4
R200 000 – R299 000	5
R300 000 or more	6

(b) Please tick the major source of funding:

National Research Foundation	1
THRIP	2
Innovation Fund	3
University/ Technikon	4
Business/ private sector	5
Overseas funder/ foundation	6
Medical Research Council	7
Agricultural Research Council	8
Other (e.g. Water Research Commission) Specify: …………………………………………….	9

18. (a) Which TWO of the following best describe the overall expected value/ outcome of the research? (*Tick the TWO that are most appropriate*.)

To advance/ improve knowledge	1
To solve theoretical problems	2
To solve immediate technical or applied problems	3
To develop skills	4
To train students	5
To change behaviour/ attitudes/ values	6
To influence decision-makers	7
To change legislation	8
To develop new technology	9
To improve product or technical design	10
To engineer a prototype	11
To enter new markets	12
Other (Specify: ……………………………………………………………………)	13

(b) Please rate the extent to which you believe that the two expected values/ outcomes, on the whole, have been successful or not. (*You need to write the two expected values/ outcomes – indicated in 18(a) –in the spaces below before rating them*.)

	Highly successful	**Successful to some extent**	**Not successful at all**
(1) ………………………………………………………………..	1	2	3
(2) …………………………………...………………………	1	2	3

19. *Which intended beneficiaries did you have in mind when you conceptualised the research?*

Colleagues/ scholars/ peers in own discipline	1
Colleagues/ scholars/ peers in other disciplines	2
The contracting agency	3
Industry/ firms	4
Government	5
General public	6
Specific interest groups (e.g. farmers, consumers) (Specify: ………………………………………………………………)	7
Other (Specify: ………………………………………………………………)	8

20. *Did the intended beneficiaries recognise/ utilise/ implement the research as planned?*

Yes, to some extent	1
Yes, to little extent	2
No, not at all	3
Don't know	4

If <u>yes</u> (some/ little extent), please answer Questions 21(a) and (b).
If <u>no</u>, please go to Question 22.
If you <u>don't know</u>, please go to Question 23.

21. (a) Please describe how the research has been utilised/ implemented/ applied by the intended beneficiaries. (*Give concrete examples*.)

……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
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……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
……………………………………………………………………………………………………..

(b) What form of support has there been from your side? (*Training, writing a manual, etc.*)
……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
……………………………………………………………………………………………………..

Go to Question 23.

22. In your opinion, why hasn't the research been utilised/ implemented/ applied by the intended beneficiaries as planned?
……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
……………………………………………………………………………………………………..

23. *How did you communicate the results of your research? (*Please indicate the mode of communication as well as the number of outputs – i.e. the number of articles, reports, books, patents, licenses, workshops etc that resulted from this project directly or indirectly.)

Publications	**Yes**	**No**	**Nr**
Through articles in scientific journals	1	2	
Through articles in technical journals	1	2	
Through articles in popular journals	1	2	
Through contract reports	1	2	
Through books/ monographs	1	2	
Through chapters in books	1	2	
Presentations/ meetings			
Through conferences with predominantly academic audiences	1	2	
Through conferences with predominantly non-academic audiences	1	2	
Through expert committees/ panels	1	2	
Through public hearings	1	2	
Through fairs/ exhibitions/ road shows/ public talks	1	2	
Patents/ licences			
Through patenting	1	2	
Through licensing	1	2	
Training			
Through workshops	1	2	
Through the training of postgraduate students	1	2	
Cooperative interactions			
Through consultations/ technical assistance to potential users	1	2	
Through personnel exchanges/ secondments	1	2	
Organisational structures			
Through participation in consortia	1	2	
Through science parks	1	2	
Through spin-off companies	1	2	
Through technology transfer offices	1	2	
Through technology incubators	1	2	
Other (Specify: ……………………………………….………….)	1	2	

24. How many postgraduate students got their degree through the research project?

……………. *(number of masters students)*
……………. *(number of doctoral students)*

25. (a) Has there been any unintended beneficiaries of your research?

Yes	1
No	2
Don't know	3

(b) If yes, please describe (i) who the unintended beneficiaries are and (ii) how they have utilised/ implemented/ applied the research.

(i) ………………………………..……………………………………………………..……………..
……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
(ii) ……………………………………………………..……………………………………………
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26. Is there anything else that you would like to raise? Anything not covered by this questionnaire or maybe something about the questionnaire itself?

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……………………………………………………………………………………………………..
……………………………………………………………………………………………………..
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THE END
THANK YOUR VERY MUCH FOR YOUR TIME AND EFFORT

Questionnaire: Science Councils

PUBLIC SECTOR R&D IN SOUTH AFRICA:
THE PRODUCTION AND UTILISATION OF RESEARCH

A. YOUR BACKGROUND

1. Title:

Dr	1
Mr	2
Mrs	3
Ms	4
Prof	5

2. Surname: ……………………………….…………………………………………………….

3. First names: ………………………………….………………………………………….

4. Institution: …………………...…………………………………………………………..

5. Department/Centre/Division/Institute: ……………...…………………...……………………

6. Position (e.g. senior lecturer): ……………………...………………...…...…...………………..

7. How long have you been involved in research? ………………… (years)

8. Have you ever worked in government, industry or the higher education sector?

	Yes	**No**	If yes, for how many years?
Government	1	2	………………. (years)
Industry	1	2	………………. (years)
University	1	2	………………. (years)
Technikon	1	2	………………. (years)

9. Highest educational qualification completed:

Bachelors (BA, B.Tech, etc.) / Higher Diploma	1
Honours	2
Masters (M.Sc, M.Tech, etc.)	3
Doctorate (Ph.D, D.Tech, etc.)	4

10. Gender:

Female	1
Male	2

11. Year of birth: 19………….

In order to complete Section B, please select one research project that meets the following criteria:
- The project was completed in the last five years (*completion* here means that results or findings have been generated, and that the project has been reported on)
- You were the primary/principal investigator or project leader on the project
- You devoted significant research time and resources to the project.

The project you select could either be a stand-alone research study or a project within a longer-term research programme.

B. RESEARCH PROJECT

12. Title: ………...…………………..…………………………………………………………..…….
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13. Please give a brief description of the research topic (*e.g. the quantification of resistances to blood flow in the lower limb arterial system using an inverse transmission line model; current trends in the selection of students for Higher Education, etc.*)
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14. In which broad research domain(s) do the research activities mainly fall?
(*Tick all applicable categories*.)

Agricultural sciences	1
Applied sciences and technologies	2
Arts and humanities	3
Biological sciences	4
Chemical sciences	5
Earth sciences	6
Economic and management sciences	7
Engineering sciences	8
Environmental sciences	9
Health sciences	10
Information and communication technologies	11
Marine sciences	12
Material sciences	13
Mathematical sciences	14
Medical sciences: basic	15
Medical sciences: clinical	16
Physical sciences	17
Social sciences	18
Other (Specify: ………………………………………)	19

15. What triggered the research? (*Tick all applicable statements.*)

Previous research by yourself	1
Own curiosity or research interest	2
Colleague(s) approaching you to form part of a team	3
An outside firm/company/institution approaching you	4
Own interpretation of the immediate/ future environment	5
A funding agency requesting proposals	6
A tender/ contract research	7
Other (Specify: ……………………………………………………………….)	8

16. (a) When (in which year) did the project start? ……...…… (year)

(b) When (in which year) did it end? ……...…… (year)

17. Approximately what proportion of your research time did you devote to this project?

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

18. (a) How much funding (grants, awards, contracts) did you receive for the project in total?

Less than R250 000	1
R250 000 – R499 000	2
R500 000 – R999 000	3
R1 000 000 – R1 999 000	4
R2 000 000 – R5 000 000	5
More than R5 000 000	6

(b) Please tick the major source(s) of funding:

Parliamentary grant	1
Business contract	2
Government contract	3
Sale of goods	4
Other (Specify: ……………………………………………………….…….	5

19. Did you collaborate with others on the project? Please indicate in which sectors they work. (*Tick all applicable categories.*)

Other science councils	1
Universities	2
Technikons	3
Government	4
NGOs	5
Industry/ business	6
Intended user(s)	7
Other (Specify: ……………………………………..…………….…….	8

20. Which THREE of the following best describe the overall expected value/ outcome of the research? Also rate the extent to which you believe that the these, have been attained or not.

		Highly successful	**Successful to some extent**	**Not successful at all**
Advancement or improvement in knowledge	1	1	2	3
Solving of theoretical problems	2	1	2	3
Solving immediate technical or applied problems	3	1	2	3
Solving environmental or social problems	4	1	2	3
Development of skills and competencies	5	1	2	3
Training of students	6	1	2	3
Change in behaviour/ attitudes/ values	7	1	2	3
Influenced decision-makers	8	1	2	3
Change legislation	9	1	2	3
Development of new technology	10	1	2	3
Improved product or technical design	11	1	2	3
Engineered a prototype	12	1	2	3
Entrance into new markets	13	1	2	3
Other (Specify: …………………………….……………)	14	1	2	3

21. Which intended beneficiaries did you have in mind when you conceptualised the research? (*Tick all applicable categories.*)

Colleagues/ scholars/ peers in own discipline (Specify: ……………………………………………………………………)	1
Colleagues/ scholars/ peers in other disciplines (Specify: ……………………………………………………………………)	2
The contracting agency (Specify: ……………………………………………………………………)	3
Industry/ firms (Specify: ……………………………………………………………………)	4
Government (Specify: ……………………………………………………………………)	5
Specific interest groups (e.g. farmers, consumers) (Specify: ……………………………………………………………………)	6
General public/ society/ community	7
Other (Specify: ……………………………………………………………………)	8

22. Have the intended beneficiaries recognised/ utilised/ implemented the research as planned?

Yes, to some extent	1
Yes, to little extent	2
No, not at all	3
Don't know	4

If yes (some/ little extent), please answer Question 23 and go to Question 25.
If no, please go to Question 24.
If you don't know, please go to Question 25.

23. Please describe how the research has been utilised/ implemented/ applied by the intended beneficiaries. (*Give concrete examples.*)
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Go to Question 25.

24. In your opinion, why hasn't the research been utilised/ implemented/ applied by the intended beneficiaries as planned?
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25. What form of support did you give to the intended beneficiaries? (*Training, writing a manual, etc.*)

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26. How did you communicate the results of your research? (*Please indicate the mode of communication as well as the number of outputs – i.e. the number of articles, reports, books, patents, licenses and workshops that resulted from this project directly or indirectly.)*

Publications and documents	Yes	No	Number
Articles in refereed scientific journals	1	2	
Articles in refereed technical journals	1	2	
Articles in popular journals	1	2	
Contract reports	1	2	
Books/ monographs	1	2	
Chapters in books	1	2	
Published conference proceedings	1	2	
Written input to official policy documents	1	2	
Technical manuals	1	2	
Presentations			
Presentations to predominantly academic audiences	1	2	
Presentations to predominantly non-academic audiences	1	2	
Presentations to expert committees/ panels	1	2	
Presentations at public hearings	1	2	
Presentations at fairs/ exhibitions/ road shows	1	2	
Patents/ licences			
Through patenting	1	2	
Through licensing	1	2	
Training and supervision			
Training through workshops	1	2	
Training through coursework	1	2	
Supervision of masters and doctoral students	1	2	
Cooperative interactions and informal meetings			
Consultations/ technical assistance to potential users	1	2	
Personnel exchanges/ secondments	1	2	
Informal meetings with potential users/ teams	1	2	
Organisational structures			
Through participation in consortia	1	2	
Through science parks	1	2	
Through spin-off companies	1	2	
Through technology transfer offices	1	2	
Through technology incubators	1	2	
Other (Specify: ………………………………………..………….)	1	2	

27. How many postgraduate students received their degree through the research project?
.…………… (number of masters students)
.…………… (number of doctoral students)

28. (a) Have there been any unintended beneficiaries of your research?

Yes	1
No	2
Don't know	3

(b) If yes, please describe (i) who the unintended beneficiaries are and (ii) how they have utilised/ implemented/ applied the research.

(i) ……………………………………………………………………………………………………..
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(ii) …………………………………………………………………………………………………….
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29. Is there anything else that you would like to raise? Anything not covered by this questionnaire or maybe something about the questionnaire itself?

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THANK YOUR VERY MUCH FOR YOUR TIME AND EFFORT

THE END

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